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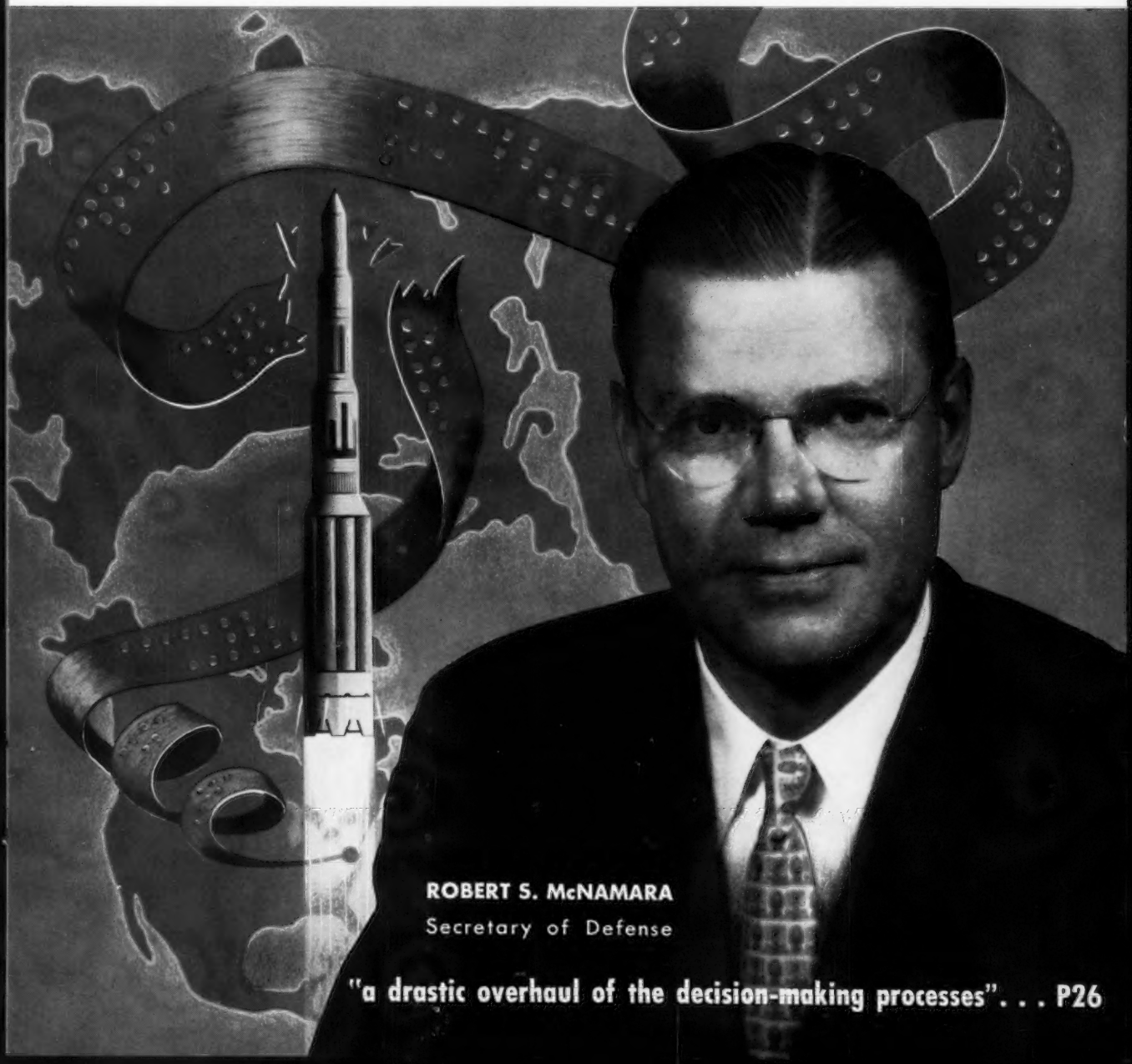
...IRCRAFT & MISSILES

AEROSPACE MANAGEMENT

FOR TECHNICAL DECISION MAKING AND LONG RANGE PLANNING

...Mission for Management—Making Defense Dollars Do More . . . P 58

...How To Get More Reliability In Electronic Systems . . . P 32



ROBERT S. McNAMARA
Secretary of Defense

"a drastic overhaul of the decision-making processes". . . P26

ARMA guides Air Force ATLAS in first full-range inertial flight

Cape Canaveral July 7, 1961. The Air Force announced the successful flight of an Atlas ICBM guided by the Arma inertial system 9,000 miles into the Indian Ocean.

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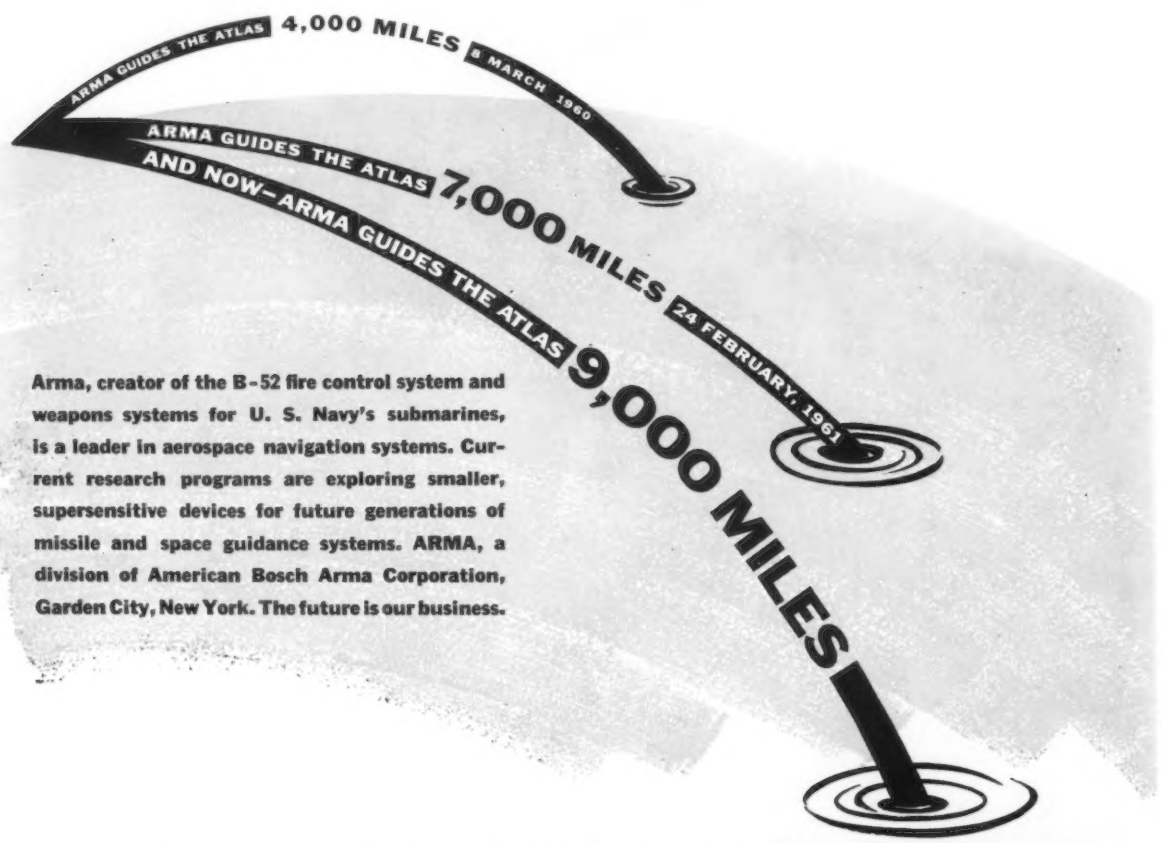
ARMA GUIDES THE ATLAS 4,000 MILES 5 MARCH 1960
ARMA GUIDES THE ATLAS 7,000 MILES 24 FEBRUARY 1961
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Arma, creator of the B-52 fire control system and weapons systems for U. S. Navy's submarines, is a leader in aerospace navigation systems. Current research programs are exploring smaller, supersensitive devices for future generations of missile and space guidance systems. ARMA, a division of American Bosch Arma Corporation, Garden City, New York. The future is our business.

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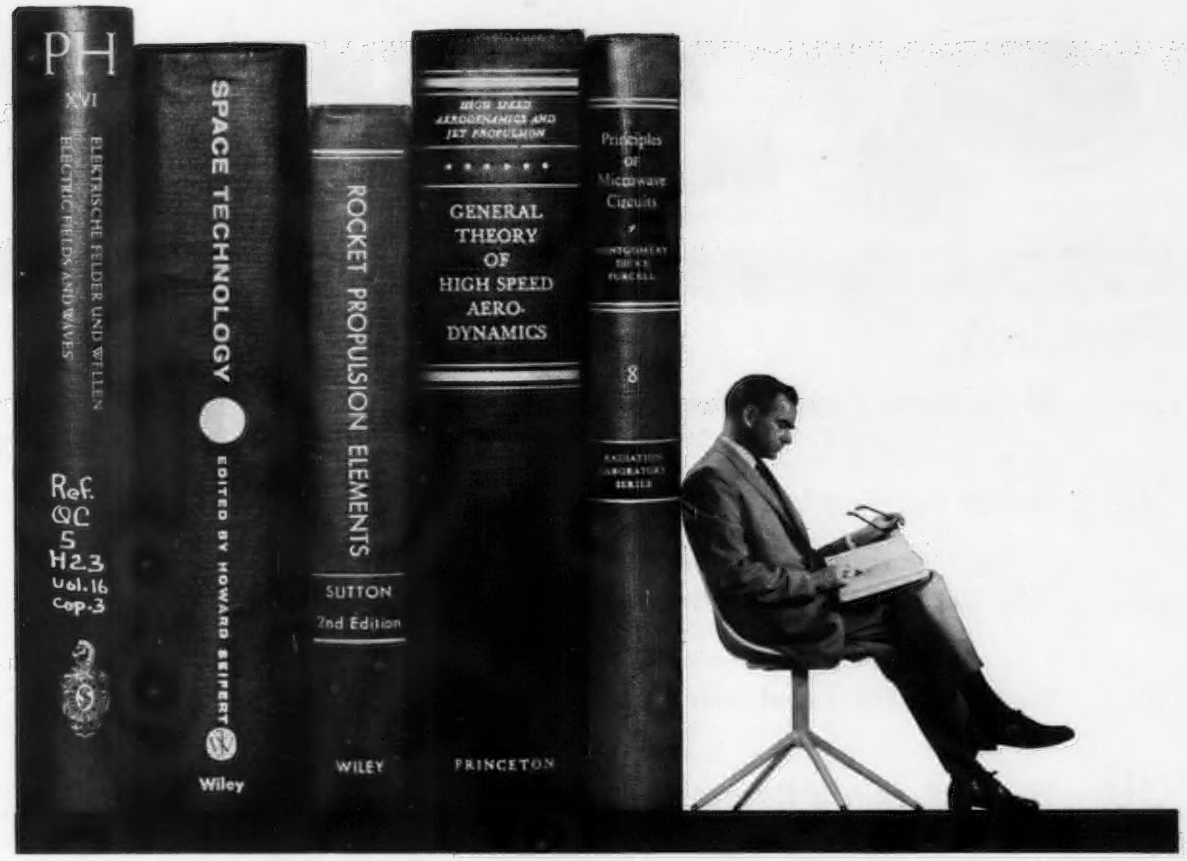

scientists and engineers in a unique leadership role

The frontiers of space science and technology are being expanded at Aerospace Corporation. The scientists and engineers of this leadership organization are the critical civilian link uniting government and the scientific-industrial team developing space systems and advanced ballistic missiles. In providing broad scientific and technical leadership to every element of this team, they are engaged in a balanced program of activities spanning the spectrum from basic research and forward planning through general systems engineering. Included in the latter are technical supervision, integration and review of the engineering, development and test operations of industry to the extent necessary to assure achievement of system concept and objectives in an economical and timely manner. These people are privileged to view both the state-of-the-art and system development in their totality. Now more men of superior ability are needed: highly motivated scientists and engineers with demonstrated achievement, maturity, and judgment, beyond the norm. Such men are urged to contact Aerospace Corporation, Room 173, P. O. Box 95081, Los Angeles 45, California.

Organized in the public interest and dedicated to providing objective leadership in the advancement and application of space science and technology for the United States Government.

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AEROSPACE MANAGEMENT

FOR TECHNICAL DECISION-MAKING AND LONG-RANGE PLANNING

August, 1961 Volume 4, Number 8

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TARGET FOR MANAGEMENT—"Bullseyeing" the right men to "sell" is often a difficult task in the complex aerospace industries. IN THIS ISSUE: How to gear your technical planning and marketing activities to mesh with the procurement patterns of Air Force, Navy, Army, NASA, and the weapon systems managers.

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IN OCTOBER —— LOOK FOR

SECOND ANNUAL FORECAST ISSUE—The progress of the aerospace industries over the coming years will hinge largely on how effectively funds restricted by economic sanity are managed. Management must establish realistic goals. The future of the aerospace industries will be projected in this Second Annual Forecast Issue.

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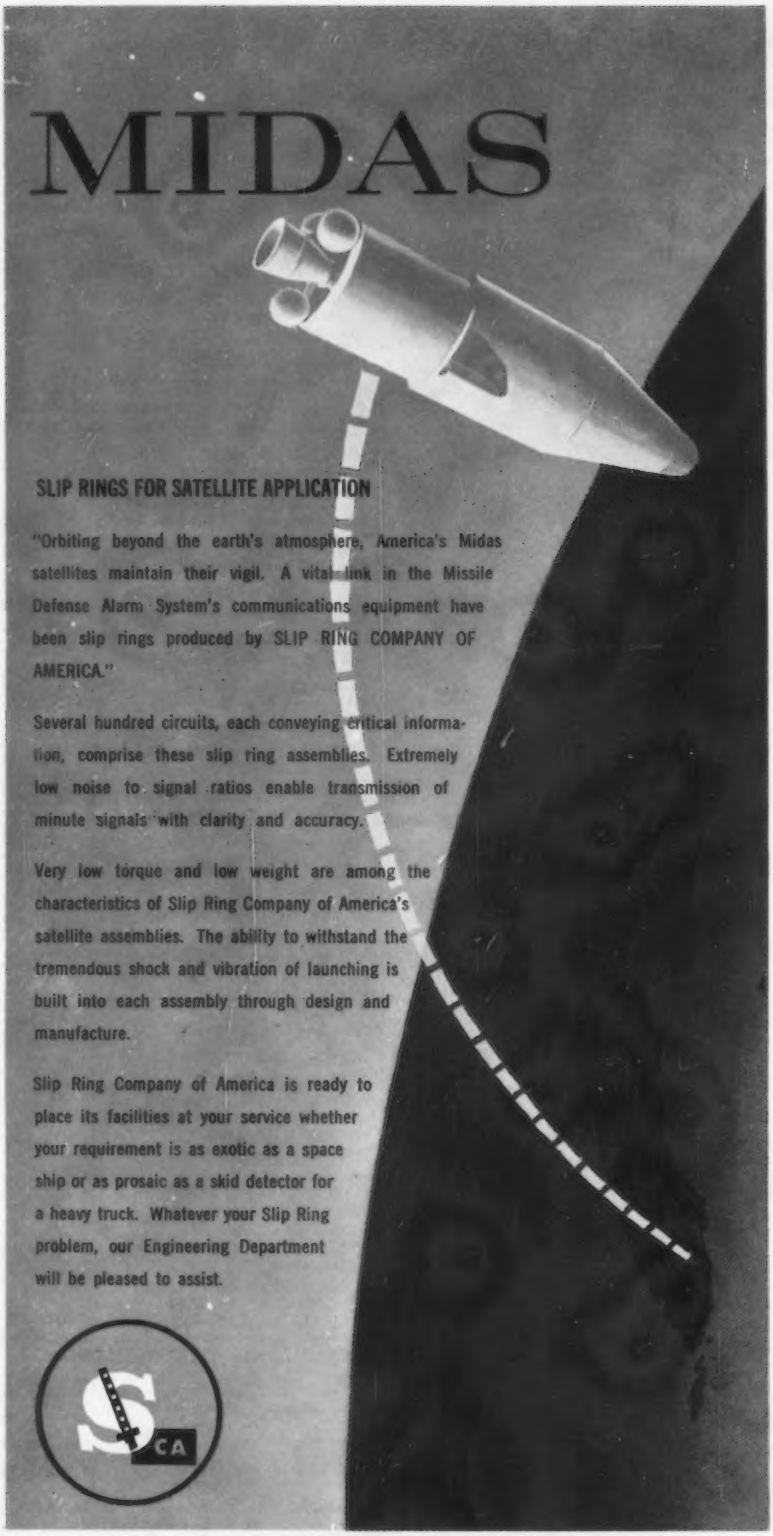
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Guidance and Control of Aerospace Vehicles: Short course
University of California
Los Angeles, Calif.

August 14-25

Design of Experiments and Time and Frequency Measurements
Special Summer Courses
George Washington University
Washington, D. C.

August 16-18

Circuit Packaging Symposium
International Meeting
University of Colorado
Boulder, Colo.

August 16-18

International Hypersonics Conference
American Rocket Society
Mass. Institute of Technology
Cambridge, Mass.

August 22-25

Western Electronic Show and Convention
The Cow Palace
San Francisco, Calif.

August 23-25

Gas Dynamics Symposium
American Rocket Society
Northwest Technological Inst.
Evanston, Illinois

August 25-28

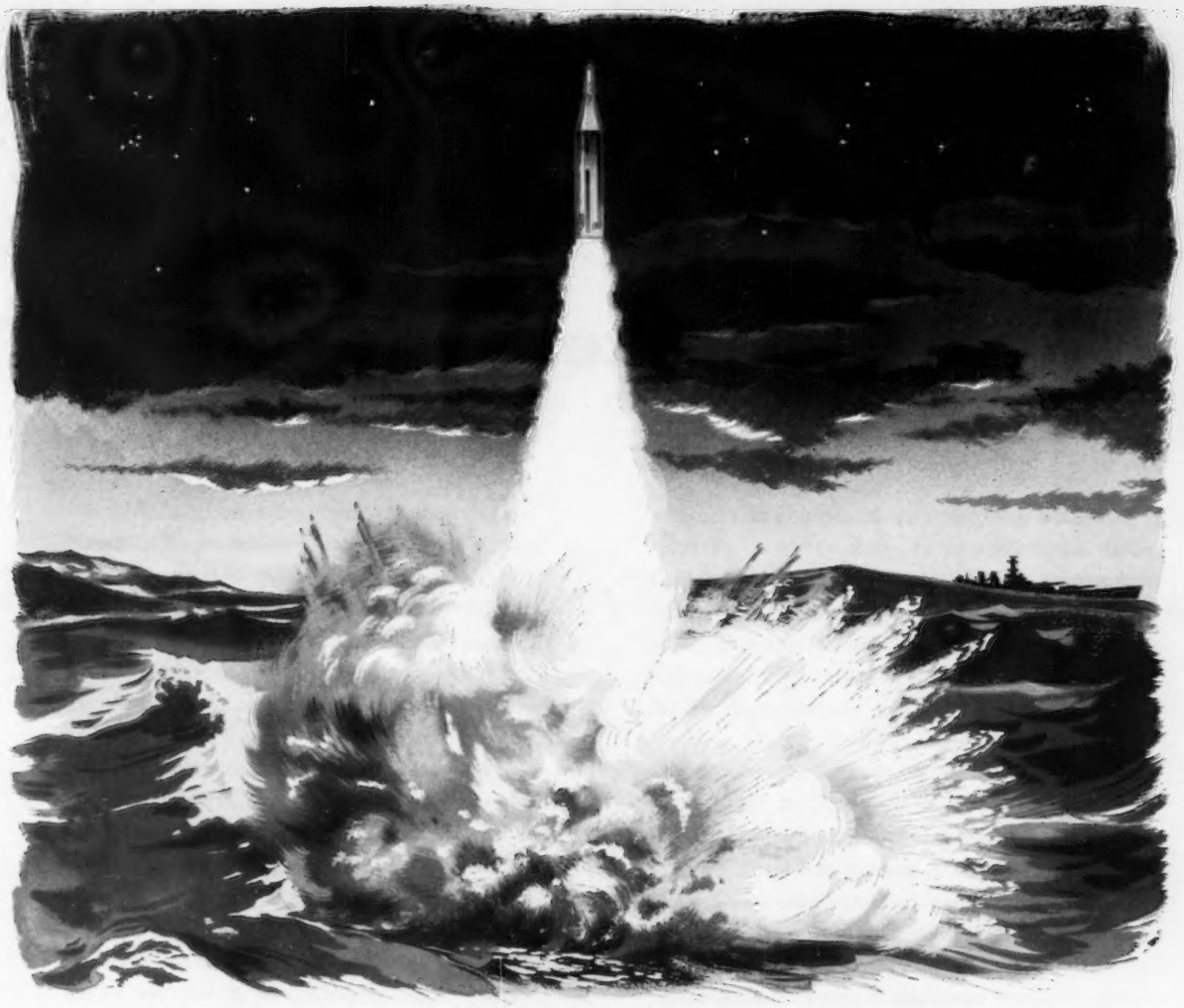
International Conference on Creep and Fracture
ASME, IME and ASTM
Hotel Biltmore
New York, N. Y.

August 27-Sept. 1

Seminar on Materials Under Thermal Stress
Education Information Office
Pennsylvania State University
University Park, Penna.

September 6-8

Joint Nuclear Instrumentation Symposium
ISA, AIEE and IRE
North Carolina State College
Raleigh, North Carolina



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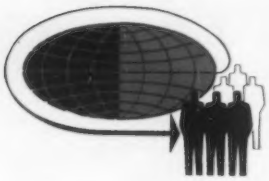

EDITORIAL

Why—Aerospace Management?

Aircraft & Missiles has changed. Yes, changed to an even more important and dynamic publication—Aerospace Management.

We invite you to read each and every article. Look it over carefully. Now, for the first time, you've got a magazine exclusively devoted to the techniques of managing the complex programs of the aerospace industries.

No doubt, you're asking why the new concept. Mainly, it was brought about by you, the reader. Over the past several months, we published more and more management-oriented articles. The more we ran, the more you asked for. Those with a management role in research and development, engineering, production, procurement, and marketing wanted to know more about how to manage technical programs. Letters came in great quantity. Readers said that they could not get management material elsewhere. True, there was very little to be had on management subjects dealing with the aerospace industries.

Interviews with industry and government leaders reinforced your letters and our research. This was a mandate for a magazine like Aerospace Management, the publication for technical decision making and long range planning.

How does this publication propose to help those with management responsibilities? Taking that look inside is the best answer. The proof is in the articles. Let's go on a quick tour of this issue.

There's an interview with Secretary of Defense McNamara giving his views on military and industry management of our defense programs.

A special management report on solids versus liquids sums up the battle for big booster contracts. You'll know who is on each side.

Our new Organizing for Success series tells how "You Can Get More-Reliable Electronics." This is part of the RCA, AGREE program.

You won't want to miss "How UTC Invaded a Major Market" in the new Big Decisions series. Find out why United Aircraft invested $30 million in starting a company that didn't have one contract.

RADM. Paul D. Stroop, in another exclusive article, gives vital information for management in "Making Defense Dollars Do More." And, that's not all. There are many more equally important articles in this issue. More time could be spent here telling you about each feature. We would rather have you see for yourself in reading them.

This is just an indication of the type of editorial diet you will get in each copy of Aerospace Management. Case histories on cost control, management control, proposals, procurement, reliability and a host of other subjects concerned with improved technical management methods and processes will be covered regularly. Most of the material will be systems or projects oriented, not theoretical management data. What we are striving for is to help those with a management responsibility to individually and collectively see that this nation gets the best weapons, and most technical progress for every dollar spent on aerospace programs.

Is this a high aim for Aerospace Management? Perhaps, but we are convinced we cannot aim lower. A magazine such as AM has a responsibility second to none in a scientific and forward-looking society.

Just one score years ago men's dreams were sparked anew at the fascination of outer space. A

"All of the major weapons systems initiated during the past several years have involved two or more major companies, and two or more governmental laboratories. These interrelationships, therefore, are focussing increased attention on the problems of program management, time phasing, prompt decision making and their corollary influence on costs and cost control. Also of great concern to the industry today is the need to develop new approaches and new techniques to bear on all aspects of management of the industry. There is urgent need to increase management capabilities and administrative techniques to efficiently exploit the scientific, technical and productive capabilities of the aerospace industrial complex."

Aerospace Industries Association
1961 Aerospace Facts and Figures

whole industry blinked, rubbed its eyes in the brightness of a new day, and technology went on a rampant pace to conquer the unknown.

Then, of course, there were gaps. Just about all kinds of gaps. We still have them. Supposedly well informed sources stated that we could close these "gaps" with money. Other sources, also supposedly well informed, claimed it wasn't money that we need, but more scientists and engineers to improve our technological position. Still a third group spoke up. These people thought we had enough money and that our technology was moving ahead at a good pace. But, they echoed a familiar plea, "let's get organized" to meet the new requirements of space.

Out of the "let's get organized" thinkers emerged some plans—real plans for action. No one individual gets credit for developing any one of the ideas. Yet, there are only a few who had the courage to put them in effect. These plans—like PERT and PEP—did not seek extraordinary sums of money or increased employment of technical people. Their goal was BETTER MANAGEMENT. They showed the way to mate men, money, and time into a simple machine to run a complex military and industrial giant. Out of these methods came Minuteman and Polaris to mention just two successful projects.

General B. A. Schriever, Commander, AFSC, speaking on "What Makes Success In A High Priority Program," stressed the importance of "management and organization."

Dudley E. Browne, vp-finance, Lockheed Aircraft Corp., in a keynote address before the Western Systems Conference, made these statements: "Organization is one of the problems we must solve before the new horizons of the future become the landscape of the present. If systems are management tools, they are tools that present us with at least two problems—we need to know how to use them, and we need to know what to use them on. . . . I do know that we need to understand more about the art of management."

Yes, military and industry want better management. What does it mean? Simply, better reliability, more efficient use of our capabilities, getting the most out of every program dollar, constantly striving for improvement on an organized basis. Better management means the ability to equate technology with economics. We have a name for it—"technomics."

The job of better management or using "technomics" doesn't only rest with those at the top of the management echelon. It goes deeper in any organization to all of those who have a decision making and planning role. The entire middle management and operating management structure must exert a strenuous effort to bring to fruition the technical and economic capabilities of each and every company.

Too many people have come to assume that technical strength in itself means progress and assures leadership. Too few realize that ineffective management can counteract and wreck the strongest technology.

Tom MacNew
Editor

Reader's Orbit

Are Gov't Specs Dying?

...Re: "The Fight For Purchased Parts Quality" (June 1961).... Contractors are buying to company specs, rather than military specs, because:

(1) Rapid growth of the missile industry has far surpassed the ability of the Government to up date specs. . . .

(2) There is a mistaken belief that specs must be used "as is," rather than with specific deviations which would make the specs suitable for use. . . .

(3) Today's young engineers are nearer being scientist than engineers. . . . They consider spec preparation to be a menial task to be performed by technicians. . . . They do not realize that a specification is the only product of an engineer. . . .

. . . What can be done about this?

(a) Agree that the situation exists.

(b) Only proper education can correct the rest. This means you and I, and our peers, must do all we can, and more, to foster the preparation and use of specifications. Specifications are both the products and tools of engineers and the only means by which suppliers can know the users' requirements.

Leonard S. Yarbrough
Electronic Engineer
ABMA, Huntsville

The above letter was written to Mr. G. M. Ellis, staff Engineer, Convair, taking certain exceptions to Convair's extensive in-house testing and qualification of vendor products.

Russian Missile Handbook

. . . This article will be very helpful in my background files as a member of the Science and Astronautics Committee of the House of Representatives.

Hon. James G. Fulton
27th Dist., Pennsylvania

. . . I am sure this material will prove a valuable and informative reference in my Committee activities, if I can ever be of assistance to your fine publication, please don't hesitate to contact me.

Hon. James C. Corman
22nd Dist., California

. . . "It gave a broad, graphic and very useful picture of Russian strength in missiles."

Hon. David S. King
2nd Dist., Utah

. . . Mr. Bowles . . . is most pleased to have the information (contained in the Russian Missile Handbook).

Brandon Grove, Jr.
Special Assistant to the
Secretary of State.

. . . The manner in which you presented this information makes it a very valuable reference.

Hon. Hugh Scott
Senator, Pennsylvania

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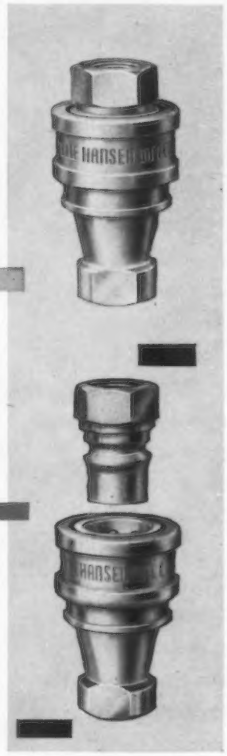

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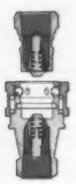

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. . . I appreciate very much having this report for my information, and have brought it to the attention of the Administrator of the National Aeronautics and Space Administration.

Hon. Thomas G. Morris
At Large, New Mexico

B-70 Pilot Comments

Re: the July issue, (Man and Machine at Mach 3+) . . . I found both articles interesting, particularly because of my close association with the B-70 and the technology that it will advance towards development of the supersonic transport.

A. S. White
Chief Eng. Test Pilot
North American Aviation

More Progress on SLAM

. . . I wish to compliment you on a very fine and accurate article—"Nuclear Ramjet Propulsion—Problems in Progress" which you published in May . . . the reactor and feasibility demonstration that were conducted at Jackass Flats during May . . . adds significantly to the progress that you have already reported upon.

W. J. Hesse
SLAM Project Mgr.
Ling-Temco-Vought

Dual Interest In Integrity

. . . I think you have achieved an editorial first. The fine "STATE YOUR CASE" series you have been running has drawn the attention and recognition of one of your competing magazines. Mr. Denham Scott's provocative "Integrity vs. Low Bidder" evoked comment by the editor himself in the July 24 issue of (a national missile space weekly).

Pete Matei
Materials Consultant
Hazleton, Pa.

Missing Persons

. . . Re. "Materials Selector for Propellant Systems" (A&M, Feb. 1961) by Eugene M. Tomlinson, Development Engineer, Aerojet General Corporation. We have had difficulty in locating Mr. Tomlinson and were wondering if you would be able to give us his complete address.

G. M. Taylor
Penton Sales
Hercules Powder Co.

Your difficulty ends here—address is: Aerojet General Corp., Liquid Rocket Plant, PO Box 1947, Sacramento, Calif.

Presidential Praise

. . . Re. "Republic Gears For Space" (A&M, June 1961). The article on Republic was very well done. I enjoyed reading it.

Mundy I. Peale, Pres.
Republic Aviation Corp.
Farmingdale, New York

Staying Power

. . . would appreciate two copies of an article entitled "Performance and Cost Evaluation at Northrop," by E. Nolan, V. P. and General Manager Northrop Div.

Joseph Furrow
Torrance, Calif.

We normally have enough reprints to meet reader requests for two or three months following the date of publication. But, this article was published in December 1958. That's what we call staying power.

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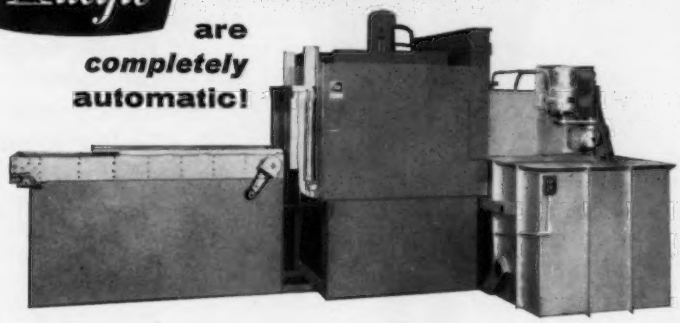

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THE Bendix CORPORATION

Photos below: material samples exposed to supersonic jet torch at a heat flux of 400 btu/ft²/sec. (approximately 3000°F.)

Chrome Composite
15-minute exposure

Graphite
4-minute exposure

Molybdenum
45-second exposure

Chromium
3.5-minute exposure

Project Progress

Missiles and Space Vehicles

AEROBEE-HI — Nose cone which operates similar to the Venus-fly trap (reported here last month) brought unexpected results. Air Force scientists discovered what appears to be a dense band of micrometeorites which envelopes the earth at extreme altitudes. A Nike-Cajun was launched June 23 with instruments in the nose cone which might pinpoint the belts location.

APOLLO—After initial studies, Martin Co. concludes that man will contribute more to a space flight system than the machines which would be required to take his place. He will also furnish a capacity for decision-making and observation impossible to duplicate.

ATLAS—First link of an ultra-reliable intersite communications system at the Schilling AFB Atlas site has been completed. Buried, blast-resistant system will ultimately join 12 launch compleses to the central command post, which will be linked to SAC's alert system.

ATLAS AGENA-B—Scheduled for initial Advent tests as well as Project Rebound. Atlas Centaur programmed for final Advent series.

KIWI B—First Kiwi B test reactor to be ground tested in Oct. 1961 leading to power runs every two months in 1962 in accelerated test phase of Project Rover. B reactor uses gaseous hydrogen, similar reactor will use liquid hydrogen for the first time in early 1962.

KIWI B—Flight weight nozzle designed for nuclear rocket engine will be used in Kiwi B tests tentatively scheduled to start in Oct. Constructed of Inconel X, the nozzle will be cooled by liquid nitrogen.

MACE B—Martin built Mace B has completed development phase. When Mace B nears target it sheds its 23 ft wing and goes into a ballistic dive at supersonic speed. With a range of 1200 mi, Mace B will supplement Mace A and Matador.

MERCURY—NASA will test the recently completed worldwide Mercury tracking network. Satellite to be used in test, called Mercury-Scout I, will follow same orbital path which will be used for Mercury manned orbit.

MINUTEMAN—Brine chiller airconditioning system for minuteman railroad cars to be designed and built by Telecomputing Corp.'s Advanced Structures Division.

NERV II—Aerolab Development Co. to build vehicle system to carry recoverable payload 1200 mi into space over a 1200 mi range. System includes four-stage solid propelled Argo D-8, also built by Aerolab. NERV (Nuclear Emulsion Recovery Vehicle) launch is expected late this year.

NIKE-ZEUS—General Electric will build 12 Atlas Target Vehicles to be used in testing. Nike-Zeus anti-missile missiles will be capable of intercepting an enemy missile over 200 mi in space.

NIKE-ZEUS system will use more resistors and transistors than the present production facilities in the U.S. would be able to produce. With a 5-million-a-month use figure in mind for resistors, Western Electric developed an automated production line at Winston-Salem, N. C., to meet the demand. Bell Telephone has done the same thing in the transistor field at Nutley, N. J.

OAO—Satellite memory system, being built by IBM for Orbiting Astronomical Observatory, will store data and radio it to ground during time it is within range of ground stations. Instructions for experiments can also be sent up and lodged in a smaller memory. OAO will be launched in 1963.

PERSHING — Successful firing from transporter - erector - launcher (TEL) mounted on fully-tracked prime mover (XM-474) with impact in preselected target area marked twin success for concurrency concept in weapons system development.

POLARIS—More than two-thirds of the 1960 Polaris missile system funds passed to subcontractors and suppliers. Lockheed received $427-million of which $295-million went to other companies, 85 per sent with small business.

Project Progress

continued

REBOUND—NASA study contract to Douglas Aircraft for developing orbital placement technique and engineering design specifications. Three inflated balloon-type satellites, larger and more rigid than the 100 ft Echo I, are to placed into orbit with one launch vehicle. Present plans place six satellites in orbit during 1963 using two Atlas Agena-B vehicles.

SATURN—Study contracts to determine the potential performance of the Saturn booster using nuclear stages have been issued to Convair and Lockheed.

SATURN S-II—Aerojet, Douglas, GD/Astronautics, and North American invited by NASA to submit detailed proposals on the design, development and production of the S-II stage. Target date for advanced Saturn with S-II launch set for late 1964 or early 1965.

THOR-ABLESTAR—Air Force booster successfully launched three satellites into space. Ablestar was first rocket engine to be restarted in space. Transit IV-A satellite contains a SNAP nuclear auxiliary power source, and is fourth satellite in series to develop all weather, worldwide navigational system. Greb-III will measure x-ray radiation from the sun. Injun satellite will measure cosmic radiation in the Van Allen belt and investigate Arctic aurora.

TYPHON—Bendix was selected to develop a long range Typhon missile following an extensive management and technical evaluation program by the Bureau of Naval Weapons. System will consist of shipboard units, radar, launching systems and missiles.

Aircraft and ASW

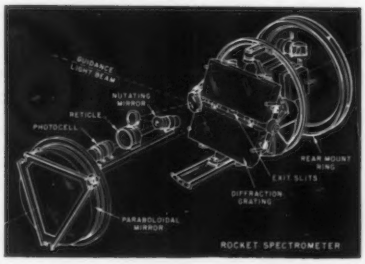
ARTEMIS project hopes to locate submarines at long range. A transducer weighing hundreds of tons, five stories high will be lowered into the water from a modified Navy tanker to test feasibility of high-powered sonar transducer with high gain receiver.

BOEING VERTOL 107—Class 1 provisional certificate issued by FAA. New York Airways will put first 107s into operation later this year.

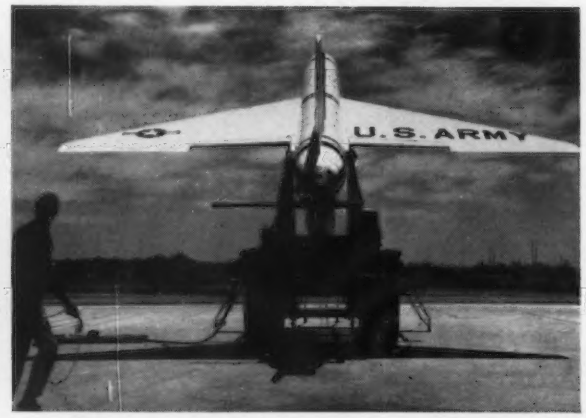
B-52H—Thousand hour test program started at Edwards AFB will involve a half-million miles of

VULCAN-SKYBOLT TEAM, shown in scale-model Mark II Vulcan bomber with two Skybolts.

AEROBEE-HI rocket will carry spectrometer to study ultraviolet energy emitted by stars. Perkin-Elmer designed for Princeton University Observatory.



MARS three-story space station model at General Dynamics/Astronautics holds three men on laced nylon acceleration couches. Station is 24 ft high, has 10 ft diam with piggyback room arrangement.



AN/USD-5 surveillance drone is 36 ft long and has 24 ft delta wing span. Fairchild Stratos designed and developed inertially guided jet-powered drone with Army Signal Corps.

flight to verify B-52H systems capability under actual service conditions.

CONVAIR 880-M—FAA has issued a provisional ticket for the jet airliner. 880-M is equipped with more powerful jet engines than the 880, each engine develops 11,650 lb thrust. 880-M has increased fuel capacity and range and has shorter landing and takeoff capability.

C-140—Lockheed has received FAA Class 1 Provisional Certificate on its C-140 JetStar. Four-engine, 550 mph jet transport to begin operations with Air Force and corporate fleets later this year.

CF-104D delivery to Canada will start in October 1961 when first of 14 ordered will be delivered.

F-104J maiden flight completed at Palmdale, Cal. Three of the single place Lockheed Super Starfighters on order from the Japanese are to be made at Burbank and Palmdale. Remaining 177 fighters will be made by Mitsubishi Heavy Industries under license from Lockheed Aircraft International. Kawasaki Aircraft Co. will be prime contractor. Twenty two-place F-104DJ's on order for Japanese Air Self-Defense will be made at Burbank. Deliveries are scheduled from April 1962 through March 1963.

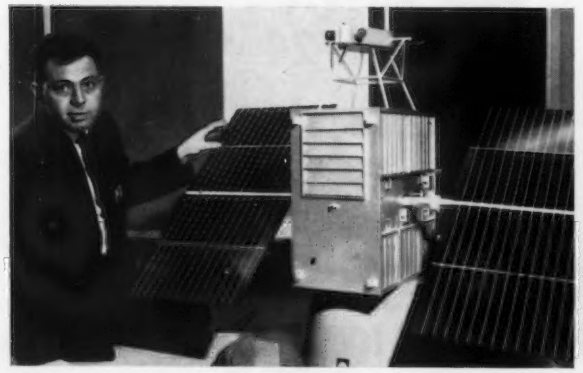
F-104 will be produced in Italy under agreement signed by Lockheed and Italian Government. Final assembly line will be in Fiat factory in Turin. Plan calls for coordinated production with other European producers. The GE J-79 engine will also be made under license in Italy.

F-105D—Republic to develop advanced all-weather reconnaissance and battlefield surveillance system which will be housed in a detachable platform that is fitted into the bomb bay of the Thunderchief. Immediately after taking photos, the unit will process, print and eject them to a ground command station.

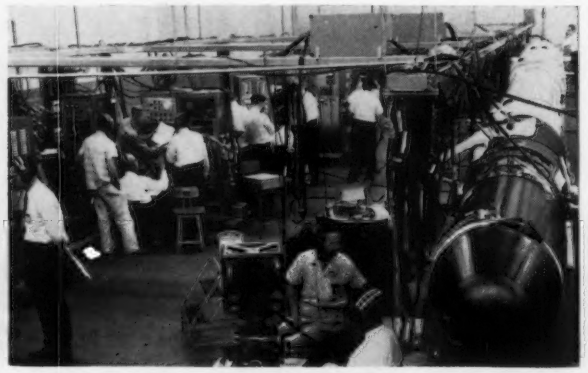
LIGHTER-THAN-AIR—Navy's Lighter-Than-Air program will be terminated by the end of November. Increased capability of helicopters and fixed-wing craft to perform ASW and airborne-early-warning function contributed to program's demise.

SUPER-CARAVELLE—Sud Aviation expects to have Super-Caravelle in service by 1967. Super-Caravelle will have Mach 2.3 capability over 1200 mi range with a maximum reach of 2500 mi.

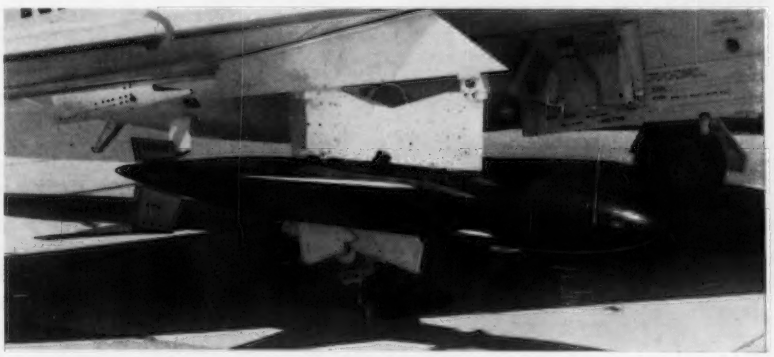
VULCAN/SKYBOLT team being checked for compatibility of plane to missile electrical systems in flights at Edwards AFB.



ADVENT comsat model and GE Advent project manager Stanley R. Sadin. Minimum system requires three comsats with one year life.



SCOUT rocket components assembly, overall systems check out and pre-launch preparation time cut to one-third by Chance-Vought handling former NASA chores.



RP-76 solid-propellant-powered target, developed by Northrop's Radioplane division, is undergoing demonstration flights for possible use as a fleet training target for Navy missiles. Target set altitude record for unmanned target aircraft of 74,000 ft. Army is using as target for Nike Hercules and Hawk.

AN

2N1015
2N1015A
2N1015B
2N1016
2N1016A
2N1016B

150 Watt

2N1212
2N1208
2N1616
2N1617
2N1618
2N1616A
2N1617A
2N1618A
2N1724

85 Watt

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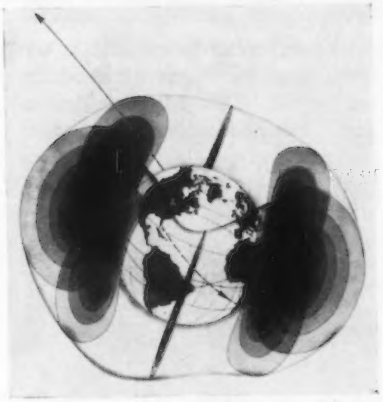
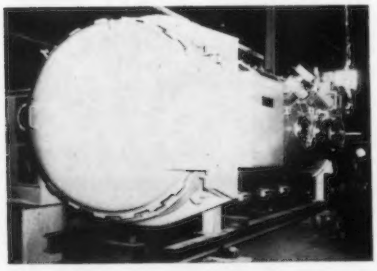
Technical Advances

R & D BRIEFS



Van Allen Radiation Belt around the earth is shown in sketch. Arrow indicates trajectory plotted to avoid greater portion of the belt by escaping along relatively clear polar regions. During its Apollo feasibility study, the Martin Co. found that the shell of a space ship and the arrangement of equipment inside it can furnish adequate protection without heavy radiation shielding.



Evacuated target chamber built by Tenney Engineering for Air Force's Arnold Engineering Development Center. Environmental chamber will be used to simulate impact of space dust and meteorites on space vehicles. Chamber measures 6 x 18 ft.

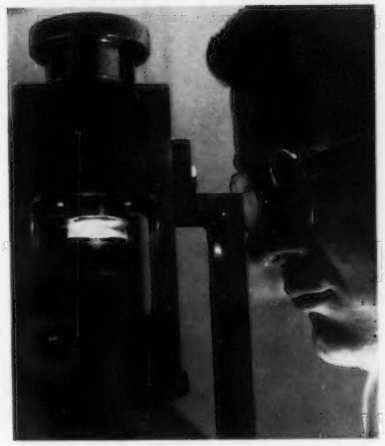
Electric energy shield to protect space vehicles, just as belt of electromagnetism protects earth, may be most practical way to save man from lethal radiation in space travel. General Electric is investigating methods of shielding space vehicles, under NASA contract.

Atomic powered automatic weather station will be located north of Canadian mainland, where it will make year-round observations. Martin-built weather station is capable of transmitting over distances up to 1500 mi. Station utilizes strontium-90 while the SNAP generator, built by Martin for Navy's Transit satellite, uses plutonium-238.

High intensity ionic jet research being performed by Plasmadyne for Air Force achieved experimental results from electrothermal plasma jets giving a specific impulse of 2000 sec on a continuous basis. Power in the plasma beam was measured directly by means of a precision calorimeter.

Solar simulator, using high-intensity Mercury-Xenon lamps, will simulate intensity of sun on vehicle in Venus orbit (275 watts of radiant energy psf). New Bausch & Lomb system can be upgraded to Mercury orbit intensities.

GEM research for Navy at AiResearch Phoenix has resulted in the design of matched fan-duct-power plant using a 150 shaft hp gas turbine. Power unit's 33 in. fan supplied 60,000 cfm through a matched diffuser and 90-deg. bend. Efficiency is said to be better than 80 per cent.



"Bullets" of water were shot into solid blocks of steel by Westinghouse researchers to study erosion effects of water droplets upon the skin of missiles and aircraft in flight. Traveling at velocities up to 3400 mph, drops of water can penetrate thin pieces of metal like a rifle bullet. Object of study is to find erosion-resistant materials for high speed service.

Space simulator nears completion at General Electric's Valley Forge Space Technology Center. The 54 ft high simulator will be large enough to test actual manned vehicles.

Conical shocktube, constructed by Navy, has produced a 75 ton blast with a five lb charge. The 180 ft scale model will aid in design of a 2000 ft shocktube in which a blastwave from a 1000 lb charge can be amplified to simulate blast of many kiloton nuclear explosion. Test, which is practically noiseless, will provide an economical means of performing ship structure radiation-free damage tests of nuclear proportions.

EQUIPMENT

Lunar chromatograph, an 8 x 8 x 10 in. black box, will be part of Surveyor space craft NASA will send to the moon in 1963. Aerojet-General is developing the unit for JPL. It weighs 11.5 lb and operates on ten watts of power.

Externally pressurized step bearing, developed by Boeing Aero-Space Div., employs a single, easily drilled opening. Pressurized air entering the shaft housing through this opening becomes trapped in a shallow recess machined on the shaft. The air lifts the shaft, becoming the bearing lubricant.

Numerically controlled machining of forging dies results in a superior finish, excellent repeatability and greater accuracy, compared with conventional machine die-forging, according to Air Force metals research study.

Gamma gauge can measure density of two dissimilar materials in proximity to one another. Developed for AEC by Nuclear Research Corp.

Electronically Steerable Array Radar (ESAR) system uses computer-controlled multiple electronic search and track beams. EASR can track space vehicles launched from Wallops Islands, Va. and simultaneously monitor airway traffic in the Baltimore-Washington area. A limited number of EASR systems would be capable of detecting and tracking any missile approaching the North American continent. Bendix Radio Div. is working under joint RADC, ARPA and DOD contract.

Cryogenic gyroscope, under development by General Electric with Army and Navy funds, would improve accuracy of inertial guidance and navigation systems for submarines and space vehicles.

Thermionic converter design, developed by Tapco New Devices Lab, delivered an actual efficiency of 13 per cent at the 200 watt power level.

Mobile clean rooms for on-site cleaning of missile propellant systems components. Ten ft wide and 55 ft long, the trailer contains five environmentally controlled rooms. Wyle Laboratories is operating trailer, providing field inspection services.

Space suit, developed for the Air Force by International Latex, is designed to enable a man to work in space. An oxygen pressurization and circulation system removes carbon dioxide, and provides cooling and moisture control. Corrugated body joints provide good mobility.

Fiberglas-reinforced plastic undercarriage has been designed for use on the STOL MFI-10 in Sweden. Filament-wound part using Owens-Corning glass roving was made by AB Malmo Flygindustri at Malmo.

PRODUCTION

Chemical milling of aluminum-Mylar laminate preserves strength and rigidity of material, yet sheds about 30 per cent of aluminum. Resulting windows will permit some solar energy to pass through Mylar without striking reflective surface, reducing effect of solar pressure on sphere or its orbit. G. T. Schjeldahl Co. has contract for materials development.

Shear-forming research and development which Temco Electronics & Missiles Co. has been conducting for the past two years will be continued under a contract from Air Force's Aeronautical Systems Div. Tests on 32 metal alloys will be made, shear-forming conical shapes, to determine hardness, tensile strength, shear strength and microstructure of each shear-formed alloy.

Market Planning

To Prosper—Diversify

The electronics industry has grown from $2.6 million in 1950 to $10.3 billion in 1960. This rate is four times greater than the GNP over the same period.

About the only thing that has matched this growth rate is the number of companies vying for the dollars.

Last month Henry W. Harding, President of LFE, Inc. joined the growing chorus which sings, "one can see what is about to happen: an exacting toll in the form of sharply increased business mortality rates."

But LFE continues to grow. During fiscal 1960 sales were $38.5 million. This fiscal year (ending April 1961) LFE had grown to $63 million sales. How? Largely through mergers. Why LFE merged is more important. They want to build a diversified capability.

About 64 per cent of factory sales in 1959 were made by 20 firms, despite the fact that there were thousands of companies in the business. This is a high degree of concentration. Though DOD spending will stay high in the 60's, contracts will go to fewer and fewer companies. Those firms, namely large firms, capable of integrating widely diversified technologies will prosper. The highly specialized companies will fade.

FOR A SINGLE REPRINT

of the Market Planning page write on company letterhead to:

Market Research,
Aerospace Management,
Chestnut & 56th Sts., Phila. 39, Pa.

More Aircraft Money?

Decisions and events that originate in Russia have their effects down to the tap roots of our own aerospace market.

Last month the Soviets showed what was to some a surprising display of airpower at Tushino field. To others it was only a sickening materialization of what they had been warning about for years.

The display of bombers, fighters, and helicopters showed that Russia has not abandoned the airplane. In fact they have apparently gained enough confidence and sophistication to move on out ahead of the pack with their designs.

What will this do to our own aircraft industry? What will it do specifically for the "sentenced" B-58 and B-52 programs, for the undernourished B-70, for the apparently-dead Missileer and Eagle team and for the nuclear aircraft, flying-crane helicopter and the jet seaplane?

Not enough!

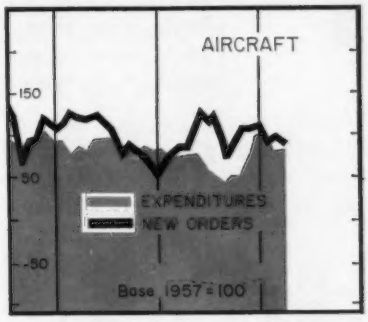
But, look for the administration to reach firmly, without appearing to grab, for the $525 million Congress appropriated for continued big bomber production. The B-52 stands to get most of this. More money for B-58 will require a major reversal.

The administration unfortunately appears determined to go slow on B-70. But renewed pressure by Senators R. Yarborough (D-Texas), John C. Stennis (D-Miss.), Clair Engle (D-Calif), Howard Cannon (D-Nev.), Stuart Symington (D-Missouri), Willis Robertson (D-Va.), as a result of Tushino, could detour about $138 million of the big bomber funds into B-70.

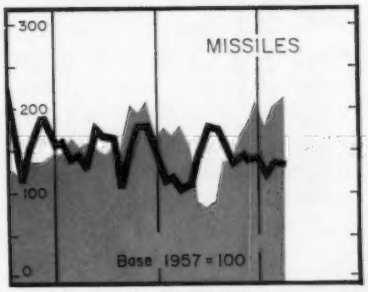
Market Planning continued on next page

DEFENSE EXPENDITURES AND NEW ORDERS

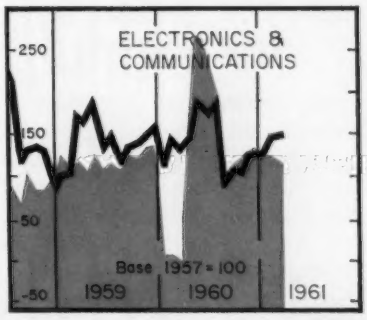
3 Months' Moving Average Index



Aircraft includes air-frames, engines armament, electronics, and other government furnished equipment. Also included: special tools, test equipment, and ground handling equipment.



Missiles graph includes complete missile systems—armament, launching, guidance, control, boosters, sustainers, propellants, special tools, and ground handling equipment.



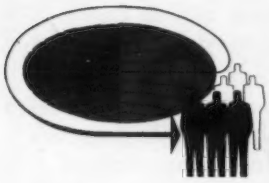
Electronics and communications graph is related to the following equipment: radar, electromagnetic equipment, computers, radiation airs, countermeasure, radiac and infrared, meteorological equipment, sonar, transmission or reception units, noise and interference detection devices, test equipment, spares, and related component equipment.

FUTURE MARKETS

are where the firings are

Projected breakdown shows space-launch schedule through 1975

Customer or Prime Agency	Utilization	Project or Code Name	Mission or Operation	Present Booster Stage	Upper Stage Designation	Booster Thrust In 1000 Lbs	Payload Weight in Lbs	Orbit Altitude in Miles	Estimated Number of Planned Flights per Year 60	61	62	63	64	65	66	67	68	69	70	Estimated Flights Between 1971-75	Estimated Total Number of Flights Between 1965-75
NASA	Meteorology	TIROS	Weather Observation Satellite	THOR	ABLE DELTA	165	270	450	2	3	–	–	–	–	–	–	–	–	–	—	—
NASA	Meteorology	NIMBUS	Same Advanced Version	THOR	AGENA B	165	600-700	700	–	1	2	2	2	1	1	2	3	1	1	30	39
NASA	Meteorology	AEROS	24-hr Satellite Weather Observation	ATLAS	CENTAUR	390	—	23,000	–	–	–	–	2	2	2	2	4	2	2	15	29
NASA	Observation	OAO	Orbiting Astronomical Observatory	ATLAS	AGENA B	390	3500	550	–	–	–	1	2	3	3	3	3	3	3	15	33
NASA	Observation	OGO	Orbiting Geophysical Observatory	ATLAS THOR	AGENA B (EGO) AGENA B (POGO) CENTAUR	390 165	1000 1500	150-60,000 170-10,000 170-650	–	–	–	2	4	5	5	5	5	5	–	15	40
NASA	Observation	OSO	Orbiting Solar Observatory	THOR	DELTA	165	350	300	–	3	3	–	–	–	–	–	–	–	–	—	—
NASA	Nuclear Test Vehicle	RIFT	Chemical Launch of Nuclear Upper Stages	SATURN, SI	NUCLEAR	1500	19,000 5,000	350 Escape	–	–	–	–	–	–	1	2	2	2	2	10	19
NASA	Exploration	MOONSHOT	Early Circumlunar Probe	ATLAS	ABLE	390	—	Escape	1	1	–	–	–	–	–	–	–	–	–	—	—
NASA	Exploration	MERCURY	Man-in-Space Early Satellite	REDSTONE ATLAS	— —	78 390	2400	120	1 –	10 7	– 6	– 1	–	–	–	–	–	–	–	—	—
NASA	Exploration	APOLLO	3-Man Space Capsule, circumlunar and orbital flights	ATLAS SATURN, SI	AGENA B SIV, SV	1500	20,000 8,500	300 Escape	–	–	3	3	1	2	2	2	2	2	2	10	22
NASA	Observation	RANGER-1-2	Interplanetary Flights	ATLAS	AGENA B	390	700	Escape	–	2	2	2	1	–	–	–	–	–	–	—	—
NASA	Exploration	RANGER-3-4-5	Hard Lunar Landing	ATLAS	AGENA B	390	2,500	Escape	–	–	3	–	–	–	–	–	–	–	–	—	—
NASA	Exploration	SURVEYOR	Soft Lunar Landing	ATLAS	CENTAUR	390	2500	Escape	–	1	4	5	4	4	4	–	–	–	–	—	8
NASA	Exploration	PROSPECTOR	Soft Lunar Landing and Return	SATURN, SI	SIV, SV	1500	2500	Escape	–	–	–	–	–	1	1	1	1	1	1	5	11
NASA	Exploration	MARINER	Mars and Venus Probe	ATLAS	AGENA B CENTAUR	390	8,500 1,500	300 Escape+	–	–	1	2	1	1	1	1	–	–	–	15	18
NASA	Exploration	VOYAGER	Advanced Planetary Landings	SATURN, SI	SII, SIV, SV,+	1500	—	Escape+	–	–	–	–	–	1	1	1	1	1	1	5	11
NASA	Exploration	MAN-ON-THE MOON	Manned Lunar Landing and Return	NOVA (F-1)	—	10,000	135,000	Escape	–	–	–	–	–	–	–	–	1	2	2	15	20
NASA	Communication	ECHO	Passive Communication Satellite	THOR	DELTA	165	130	1000	2	1	1	–	–	–	–	–	–	–	–	—	—
NASA	Communication	REBOUND	Same Advanced Version (multiple)	ATLAS	AGENA B	390	—	—	–	–	1	10	15	20	2	2	2	2	2	—	30
INDUSTRY	Communication	INDUSTRY PROJECT	Commercial Communication Satellite	UNKNOWN	—	—	175	2200	Unknown											—	50
ARMY	Communication	COURIER	Repeater Communication Satellite	THOR	ABLE STAR	165	475	650	1	4	–	–	–	–	–	–	–	–	–	—	—
ARMY	Communication	ADVENT	24-hr Stationary Repeater Satellite	ATLAS	AGENA B	390	600	22,300	–	2	2	2	2	3	–	–	–	–	–	15	18
NAVY	Navigation	TRANSIT	Beacon Satellite for POLARIS Subs	THOR	ABLE STAR	165	230	230-480	2	4	6	6	8	8	8	8	8	8	8	40	88
AIR FORCE	Surveillance	SAMOS	Photographer Satellite w/Recovery	ATLAS	AGENA B	390	4000	250-300	3	10	20	8	8	8	6	6	6	6	6	30	68
AIR FORCE	Surveillance	MIDAS	ICBM IR-Detection Satellites (8-12)	ATLAS	AGENA B	390	5000	300	–	3	10	10	10	10	8	8	8	8	8	40	90
AIR FORCE	Surveillance	SAINT	Ground-Launched Inspection Satellite	ATLAS	AGENA B	390	3500	500	–	4	4	4	8	6	6	6	6	6	6	30	66
AIR FORCE	ICBM Defense	BAMBI	Satellite and AICBM	ATLAS	AGENA B	390	—	—	–	–	–	2	4	6	6	6	6	6	6	30	66
AIR FORCE	Satelloid	DYNA SOAR I	Reconnaissance and Bombing Glider	TITAN II (SATURN)	TITAN 2nd+	400	2-2.5 Tons	60	–	–	2	2	4	3	3	–	–	–	–	10	16
AIR FORCE	Space Plane	DYNA SOAR II	Reconnaissance and Bombing Glider	SATURN		1500	—	—	–	–	–	–	–	–	–	–	–	–	–	—	—
AIR FORCE	Satellite Test Vehicle	DISCOVERER	—	THOR	AGENA B	—	—	—	–	–	–	–	–	–	–	–	–	–	–	—	—



Business Activity

Army Modernizes To Cut Costs

Army's program to provide its front-line troops with better combat aircraft will also achieve widespread cost reductions.

By 1970 nine different aircraft now in use will be replaced by six helicopter and fixed-wing models.

The Army Aircraft Requirements Review Board initiated the program in 1959. Since that time the effort has been a military-industry team affair with the Navy, Air Force and NASA cooperating to give Army the best available military-civilian counsel.

Nearly complete conversion from piston engines to turbines and standardization of fuels will result in major savings. The more efficient turbines will require less maintenance. This will reduce time and expense involved in training large numbers of mechanics. Fewer models mean fewer parts, saving on storage, transportation and manufacture.

Many different grades of fuel are required by the 9 different models being phased out. Soon, only two or three grades of fuel will be needed. Eventually all craft at the infantry division level will utilize the same grade of kerosene, which will simplify frontline logistics.

Army has about 5500 aircraft now. By 1970 they will have about 8000 helicopters, fixed wing and VTOL craft. More important than the increased number is the fact that these aircraft will be specifically designed for observation, surveillance, target acquisition or transport mission. The models being phased out were produced under World War II or Korean War pressures. The resultant hodgepodge required unreasonable amounts of maintenance and lacked the desired degree of reliability.

The specific aircraft involved in the modernization include:

Observation Helicopter — New turbine driven craft will replace the L19, N13 and H23. Four-place machine is for use at company, battalion and combat command level.

Combat Surveillance Aircraft— Fixed-wing, AO1 Mohawk is built by Grumman Aircraft. Powered by twin turboprop engines, the STOL Mohawk is now being delivered to troop units. It is equipped with the latest in radar, photographic and other surveillance equipment.

Utility/Tactical Transport—Already in quantity production, the Bell Iroquois (HU1) helicopter will replace the L20, H19, H34 and H21. Its turbo-shaft engine can be changed in 20 min. Some models will carry 7 to 11 passengers.

Transport Helicopter — Vertol-built Chinook (HC1B) will replace the H37, H34 and H21. The Chinook, with twin turbo-shaft engines can carry a cargo of five tons for short distances.

Transport Airplane — New STOL, De Havilland-built Caribou (AC1) will soon be used by troops in the field. It replaces the U1A. The twin-engine craft with a three ton capacity will be used as a battlefield transport within field areas.

Utility Transport Airplane— Seminole (L23F), built by Beech is a commercial model plane adapted to a wide range of Army uses.

Two new drones are being tested for use in target acquisition work. They will supplement the capabilities of the manned Mohawk.

Army recognizes the need for a flying crane. There will be an increasing need for such VTOL equipment. Initial plans call for a crane that can lift an 8 to 12 ton load and carry it about 25 miles. It could be used for rapid, up-front loading and unloading of vessels, or quick emplacement of bridges, missile system equipment or other heavy equipment.

PERT for ARGMA

U. S. Army Rocket and Guided Missile Agency is introducing PERT (Program Evaluation Review Technique) into specific areas of the Nike Zeus program.

By feeding regularly prepared program summaries into a computer at Redstone Arsenal, the Army project leaders can get quick evaluations of the program's effectiveness.

Brig. Gen. John G. Zierdt, ARGMA Commander, commenting on the need for such a system: "We want to nip potential trouble spots quickly beforre they become red lights that would have far reaching effects."

Initially developed by the Navy, the PERT system was used in the management of its Polaris program.

Non-Profit Group For Army Research

Army will use a private, nonprofit organization to make objective appraisals of the impact of an expanding technology on advanced strategic and tactical weapons concepts and systems.

Studies by Army indicate an increased requirement for scientific support in short and long-range analysis. At present, mid-range analysis is provided by contact with universities.

Research talent and capability presently employed by the Operations Research Office, Johns Hopkins University, will probably serve as nucleus for new organization.

continued on next page

Business Activity

continued

Business Moves

Linde Co., Division of Union Carbide Corp., building new plant near Fontana, Cal. The new plant will supply 21 tons per day of liquefied hydrogen to west coast rocket development centers under a $31-million contract awarded to Linde by NASA last Dec.

Radiation, Inc., plans to increase activities in the field of communications. The company is studying miniature solid-state switching equipment for automatically routing telephone, data and other communications links. Eventual use of such systems might be in orbiting communications satellites.

American Orbitronics Corp. has begun operations in its Washington, D. C., offices and its Hawthorne, Cal., factory. Company's products include turbine rotary wheels, inducers, rotary pumps and exotic metal nozzles and stators.

Fairchild Stratos Corp. has acquired Tribo-Netics Lab a specialist in gas lubricated bearings and will transfer the business and equipment from Vermilion, Ohio, to Bay Shore, L. I. Fairchild also acquired Advanced Precision, Inc., a small machine shop engaged primarily in the machining of high precision components of prototypes and test models for aircraft and space systems.

Major Contracts

Autonetics Div., NAA—$126-million continuation for minuteman guidance and control subsystem.

Baird-Atomic Inc. — $3.3-million for infrared detection system for Midas satellite.

Bendix Radio—$2.2-million for radar components used in ground control interception radar.

Douglas Aircraft Co.—$11.6-million for Genie components and $8.54-million for Improved Honest John components.

General Dynamics/Astronautics —$2.5-million to build three Atlas missile procedure trainers for Air Force.

General Electric Co.—$12-million for high powered, frequency diversity radar from Air Force.

General Electric Co.—$10-million from Army for Atlas-launched target vehicles to test Nike Zeus.

Gilfillan Brothers Inc.—$2.76-million for modification kits to adapt Ground Approach Control radar for use as mobile radar approach control centers.

Hallicrafters Co. — $32.3-million from Air Force for radio transmitters for use in electronics countermeasures (ECM).

Lockheed Aircraft Corp.—$22-million from Air Force for C-130 aircraft.

McDonnel Aircraft—$9-million for research and development to obtain data on re-entry vehicles.

Minneapolis-Honeywell Regulator — $3.46-million for Dyna-Soar primary guidance system.

Pratt & Whitney—$36.6-million from Navy for F8U-2N and A2F-1 jet engines.

RCA—$3-million for development on communications and data link subsystem for Dyna-Soar.

Raytheon Co. — $2.14-million from Army for Hawk field maintenance test equipment.

Sperry Rand Corp.—$16.4-million for sonar and radar work for Navy and $5.7-million from Air Force for maintenance material and parts in support of four long range search radar sets.

MANAGEMENT QUOTES

Hugh L. Dryden, Dep. Administrator, NASA to Senate Committee on Aeronautical and Space Sciences: "The billions of dollars required in this effort (landing a man on the moon) are not spent on the moon; they are spent in the factories, workshops and laboratories of our people for salaries, for new materials, and supplies, which in turn represent income to others."

George F. Hannaum, v.p. AIA, writing in Aerospace pointed out that today one-third of all U. S. plants and equipment is obsolete. He estimated the cost of modernizing American plants at $95-billion. "Depreciation presently allowed U. S. industry is estimated at some $5-billion a year less that what it should be . . . if tax depreciation policies aren't changed . . . more than half the nation's industrial plants will be outmoded by 1971. Half of our machine tools already are obsolete."

Moses Shapiro, pres., General Instrument Corp., in discussing the semiconductor industry castigated the "immature" pricing and marketing policies of "some of those in decision-making roles."

George William Miller, pres., Textron Inc.: "Military research and development in 1961 will run to about $4.7-billion, with 50 per cent devoted to missile and space projects . . . the importance of research is indicated by the fact that more money has been expended for defense and non-defense research since WW II than was spent in all prior history. Total research expenditures may rise as high as $30-billion a year by the end of this decade."

Aerospace, AIA publication, on survey indicating increase by 1970 of business, pleasure and utility planes to 100,000 compared to current 70,000: Of 3000 top industrial firms only 12 per cent fly their own aircraft. "This leaves a huge untapped market of 88 per cent who are logical customers for business aircraft in addition to thousands of smaller companies and tens of thousands of individuals."

NEW SPACE AGE FUTURES FOR

engineers

in CONNECTICUT or FLORIDA

Pratt & Whitney is expanding its operations at their East Hartford, Connecticut, Facility and Florida Research and Development Center in advanced research and development projects and long-range product planning. Current programs include: the LR115-liquid hydrogen rocket engine for Centaur and Saturn and the JSB-Mach 3 turbojet engine. Advanced Research and Development programs are exploring the fringe areas of technical knowledge in magnetohydrodynamics, thermionic and thermo-electric conversion, hypersonic propulsion, fuel cells and nuclear power for military, space and industrial applications. Openings exist at all levels of experience for engineers and scientists who want to work as part of a team dedicated to maintaining Pratt & Whitney's position of leadership in the future.

ADVANCED PROJECTS AND APPLIED RESEARCH GROUPS

For new research and development projects and long-range product planning in the fields of propulsion and power systems and their applications.

- Aero Thermo Engineers—for performance and optimization studies of all types of advanced power plant and vehicle systems including air and space craft, missile aircraft, marine and industrial applications.
- Applied Science—for advanced research and development work in the fields of nuclear, chemical and direct conversion equipment. Openings exist at BS through PhD levels in Engineering or Physics.
- Nuclear Engineers—to work with advanced concepts in reactor systems and components.

ROCKET ENGINE TEST SUPERVISORS *(Florida only)*

Experience required in the technical and administrative direction of rocket engine test complexes. Plan, schedule, co-ordinate and supervise engineers and support personnel. Broad knowledge of test equipment, facilities design and construction, test operations and support activities required.

MECHANICAL DESIGN ENGINEERING

Engineers to engage in the mechanical design of propulsion systems, including turbojet, turbo fans, solid rockets, liquid rockets, magnetohydrodynamics, nuclear and fuel cell power applications. Must have a minimum of 5 years' related experience.

ANALYTICAL DESIGN ENGINEERING

Engineers with experience in the analysis of propulsion systems design, including the fields of advanced structures, stress analysis, vibration, compressor analysis, turbine analysis and combustion and heat transfer. Must have a minimum of 5 years' related experience.

EXPERIMENTAL ENGINEERING

BSME's or AE's with 2-5 years' experience to conduct and direct rocket engine and component development. Of particular interest are those who have had engine performance, fuel and control systems experience on advanced propulsion systems.

ELECTRICAL ENGINEERS

2-3 years' experience in electromechanical, electro-hydraulic, and electro-pneumatic servo control systems; systems design, trouble-shooting, and calibration; should have good mechanical background.

TEST FACILITIES ENGINEERS *(Florida only)*

Facility engineers and test equipment designers with 4-7 years' experience in the turbojet and rocket fields.

Please submit your complete resume, including minimum salary requirements, to:

MR. P. R. SMITH, OFFICE 40
PRATT & WHITNEY AIRCRAFT
410 MAIN STREET
EAST HARTFORD 8, CONN.

— or —

MR. J. W. MORTON,
OFFICE 40
PRATT & WHITNEY AIRCRAFT
WEST PALM BEACH, FLORIDA

All replies will be handled promptly and in complete confidence.

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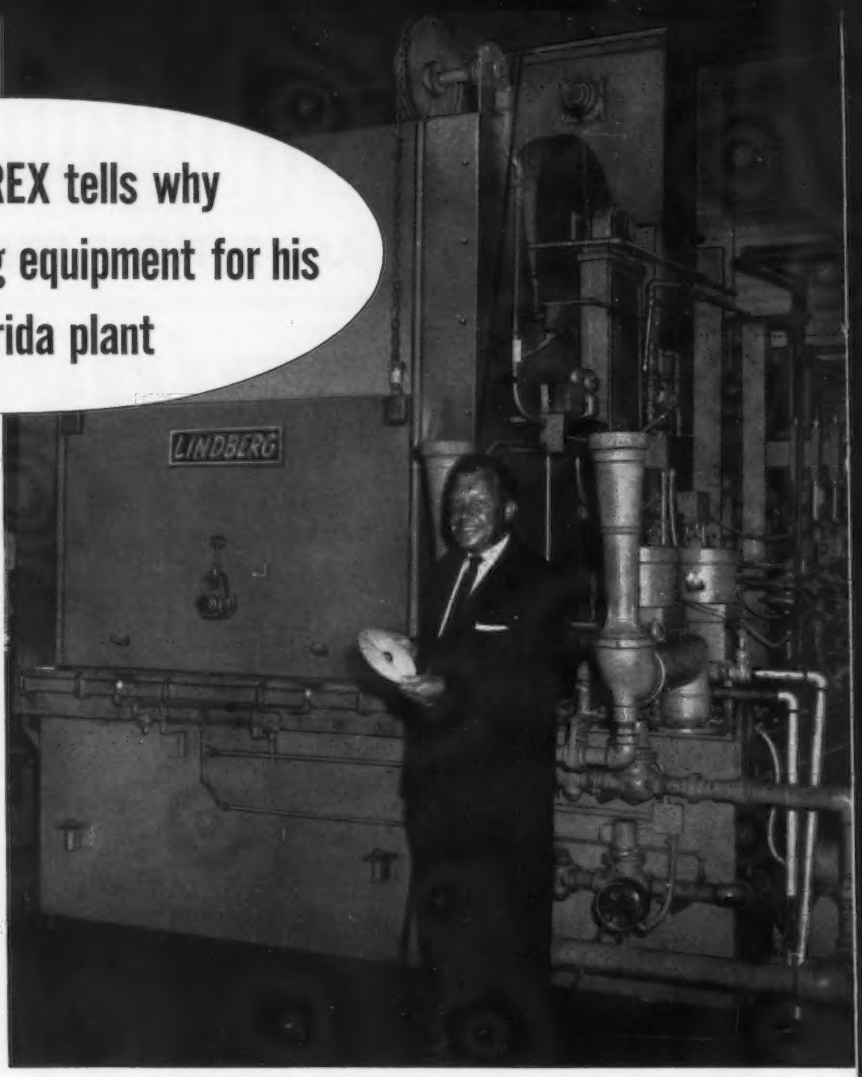
DIVISION OF UNITED AIRCRAFT CORPORATION

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

J. WALTER REX tells why he chose Lindberg equipment for his new Florida plant

QUOTE from Mr. Rex

"When we designed our new plant, Rex of Florida, Inc., we made sure we could provide the Florida metal working industry with complete heat treating services. After carefully surveying the industrial activities we would serve we knew we would be called upon to offer scientifically controlled, high quality heat treating for a variety of metals, both ferrous and non-ferrous, and an unusual diversity of sizes, shapes and weights. Our long experience with Lindberg furnaces and atmosphere controls assured us that we could depend on Lindberg equipment to help us meet most efficiently the widely varying demands of our Florida customers."



J. Walter Rex, President, Rex of Florida, Inc., Fort Lauderdale, with Lindberg high temperature, all-purpose furnace, one of six Lindberg units specified for this new plant. Mr. Rex, also President, J. W. Rex Company, Lansdale, Penna., is recognized as one of the foremost metal working authorities and his commercial heat treating operations are among the largest and most important in the country, particularly in treating components for rockets and missiles.

Latest Rex purchase from Lindberg—new vacuum furnace for Lansdale, Penna., plant

Mr. Rex's confidence in the ability of Lindberg equipment to meet the most exacting commercial heat treating requirements is based on the years of efficient and dependable service rendered by Lindberg units in his commercial heat treating operations. He has been a Lindberg customer for nearly 20 years. We're glad that he has found our equipment so satisfactory. We're very well satisfied with Mr. Rex as a customer, too. Altogether, including the units for Rex of Florida, Inc., he has purchased 34 Lindberg units over the years.

Lindberg offers the most complete line of fuel-fired and electric furnaces and equipment for heat treating ferrous and non-ferrous metals available to industry. If you have any problem in heat treating, get your local Lindberg representative's help now. You can depend on his experience and Lindberg's engineering and design know-how to provide exactly the right equipment for your need. And it's easy, too! Just call your Lindberg Field Engineer (he's listed in your classified phone book) or write us direct. Heat Treating Furnace Division, Lindberg Engineering Company, 2473 West Hubbard Street, Chicago 12, Illinois.

Los Angeles plant: 11937 S. Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg Ltd., 15 Pelham Ave., Toronto 9, Ont. Also, Lindberg plants in Argentina, Australia, England, France, Italy, Japan, Spain, Switzerland and West Germany.

LINDBERG
heat for industry

Circle 10 on Inquiry Card

Diameter, 29", Weight, 1000 lbs.
Material, Astroloy

Diameter, 24½"
Weight, 191 lbs.
Material, Titanium

Diameter, 19"
Weight, 143 lbs.
Material, High-strength steel

Length, 22"
Weight, 45 lbs.
Material, High-strength nickel-base alloy

Length, 18"
Weight, 10 lbs.
Material, Ironbase, high-temperature alloy

Diameter, 10"
Weight, 45 lbs.
Material, Inconel X

Forgings that deliver *dependable* thrust

When highest performance levels are demanded of jet engines—military and commercial—the source most often specified for critically-stressed forgings is Wyman-Gordon. Here an unmatched backlog of aircraft propulsion forging experience, dating from the industry's earliest days, gives assurance of optimum part integrity. Here a vital, continuing program of metallurgical research brings to turbine components the exceptional properties of newest exotic metals and alloys. But most particularly, here the counsel of forging specialists can help your units reach higher output levels—longer life in any thrust rating. For assistance on current or prototype designs call or write Product Manager, Turbine Applications.

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FORGINGS

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GR5

Only efficient technical management can win the air and space race. That's why Aircraft & Missiles has changed to

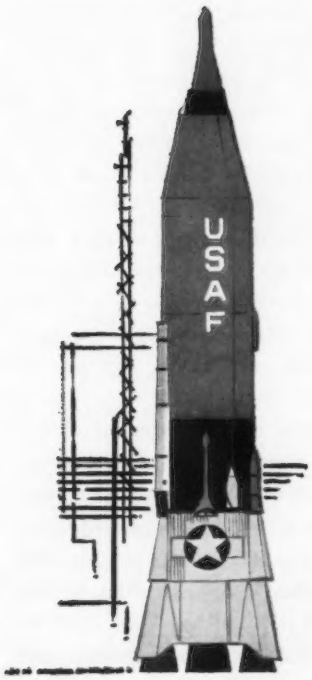
AEROSPACE

"We have never specified long-range goals on an urgent time schedule nor managed our resources and our time so as to ensure their fulfillment." **President Kennedy**

"We must work to reduce development time through real analysis, and sometimes by a drastic overhaul of decision-making processes." **Hon. Robert S. McNamara**
Secretary of Defense

"It readily can be seen that we are dealing with one of the most complex technical and management situations which could be found to exist."
General Samuel E. Anderson
Commander, Air Logistics Command

"... We are depending more upon a single contractor to pull all technical aspects of a complex weapon system together. We are encouraging use of advanced management techniques ..."
Rear Admiral Paul D. Stroop, U.S. Navy
Chief of the Bureau of Naval Weapons



What do we need to win? The nation's leaders are convinced that *management* is the vital ingredient to make our technical brainpower and superior production capability pay off.

The aerospace industry, however, is sophisticated, complex and technical. It is staffed with engineers, scientists and project leaders who have had to learn "management" on the run.

That's why Chilton has evolved AIRCRAFT & MISSILES into AEROSPACE MANAGEMENT, the magazine for technical decision-making and long-range planning. This publication will help the technical managers of our aerospace programs better streamline, tighten up and push their projects to quick, effective conclusions.

AEROSPACE MANAGEMENT's:

EDITORIAL reflects the unique management problems that confront a nation that must crash through in hundreds of new air and space projects. *No other publication serves this need exclusively.*

CIRCULATION, based upon AEROSPACE MANAGEMENT's own and exclusive census of the aerospace industry, offers advertisers the technical decision-makers and long-range planners whose needs for management knowledge are integrally linked with their needs for design and production information.

AEROSPACE MANAGEMENT is a logical step for Chilton Company, whose constant research efforts keep its magazines alert and responsive to the needs of their respective industries. Therefore, no other publication now offers such high readership potential among the aerospace industry's decision-makers as AEROSPACE MANAGEMENT. Get the full facts today.

MANAGEMENT

For Technical Decision-Making And Long-Range Planning

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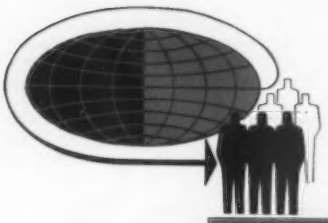
Quotations are from recent public statements.



THE VIEW FROM TOP MANAGEMENT

McNamara Views Defense Management

- *Three vital items aerospace management must look at:*
  - *Requirements*
  - *Cost-benefit ratio*
  - *Overall organization*

by Tom Mac New, Editor

Better management of defense programs is tops on the requirements list of Secretary of Defense Robert S. McNamara. This applies both at the military and industry level. The Secretary feels that too many programs have been managed inefficiently and have caused great waste. He believes that the answer is a strong management organization exercising intelligent judgment.

The first place to start saving money is in the area of requirements. Military must decide what it really needs. Industry must decide whether close tolerances and exotic materials are necessary for the fulfillment of the prescribed mission.

Secretary McNamara wants everyone to pay more attention to the relationship between costs and benefits. Specifications and performance standards must be examined to assure optimum cost-benefit ratio. We must decide, not only whether costs are low but if they are necessary.

Once a program is decided as worthwhile, the Secretary wants the military and industry to constantly suggest alternatives to that program which will give us more technological progress for each dollar spent. He thinks there is plenty of margin for savings by applying value analysis. The point of diminishing returns is still quite distant in the overall policing of such cost-cutting programs. In line with this, he believes that cost comparisons should be drawn up before and after the contract and continue right on through the engineering changes.

THE COVER STORY

Secretary of Defense Robert S. McNamara has been in office only six months. But, they have been trying months on him and the structure which he manages. Already the Secretary has called for "a drastic overhaul of the decision-making processes."

In the story which appears on these pages, the editors give some insight into what the Secretary meant when he made this cold, demanding challenge.

Also, on page 28 (Solids vs. Liquids) the editors reflect some of Sec Def's thinking on how the large solid-booster program can be rescued from the organizational red-tape in which it has been threatened to become ensnarled.

In the second place, Secretary McNamara believes, ". . . strong management effort can reduce development time. This reduction is another effective way of cutting costs. It cannot be accomplished by high-pressure methods. It must be done with real analysis, and sometimes by a drastic overhaul of the decision-making processes. One of the biggest dollar traps is the open-end work statement which invites exploration of endless technical alternatives, postponing decisions to an almost indefinite future."

Third, the Secretary states, "We must obtain more reliable cost estimates. Complex decisions require hard facts. There are enough unknowns in any military cost picture, without losing sight of cost factors that are either known or ascertainable by appropriate inquiry. Calculations that are incomplete, over-optimistic, or just plain sloppy can seriously upset our overall planning. Because we have given up dollar ceilings, we have even greater need for dollar figures as reasonably accurate, dependable measuring sticks."

What kind of a management organization does Secretary McNamara feel can achieve these goals? He believes that the military line and staff management structure can be extremely useful and has many applications in large industrial complexes. Management should gear itself to make use of computers as a decision-making aid. But, Secretary McNamara stresses that there is no substitute for managerial judgment. Decisions must be made by intelligent, technically-competent individuals.

He definitely feels that diffusion of responsibility stands in the way of timely decisions and yields only compromise. As far as committees are concerned, the Secretary frankly states, "Committees are a useful vehicle for the exchange of information and for the dissemination of counsel or advice. Except in unusual circumstances, I do not believe involving a committee in decision-making processes in place of a reliable, responsible person. A committee should seldom relieve a person of his decision-making responsibility."

The Secretary has stated before the NSIA that military has a responsibility to see that industry operations are efficient and as economical as human ingenuity can make them. With most large organizations there is a certain amount of waste and inefficiency. Industry must clean its shop. The Secretary will clean his. The first thing DOD will do toward this is devise arrangements which reward efficiency and penalize waste. Most definitely, Secretary McNamara prefers an incentive type contract as a spur to imaginative and creative thought.

Where can we look for specific examples of the kind of management the Secretary wants?

Most people will concede that a superb job was done on Polaris. The Secretary of Defense is no exception. However, management of aerospace companies should look beyond this recent success.

The Secretary considers one other project a terrific management accomplishment—the U-2. He only wishes that it had another name because of its political overtones. He considers U-2 only as a technological project that met requirements for airframe, powerplant, and control performance within an intelligent spending program. Everyone had a clear cut assignment of responsibility with streamlined decision-making processes that reduced the number of engineering changes. There is a definite similarity in both the U-2 and the Polaris programs. Neither was subjected to committee structures will ill-defined responsibility.

Battle Brewing In Bid For Big Booster Contracts

Kennedy administration has asked for $62 million in fiscal '62 to develop solid propellant boosters. Before Congress appropriates this money, important questions must be answered:

- *Can solids really close the propulsion gap?*
- *Is NASA dragging its feet in developing solids?*
- *What is the real state-of-the-art in solid propulsion technology?*
- *How much will it cost to answer these questions?*

Here Is What Management Says

by John P. Kushnerick

The Congressmen wanted to know:

"Can you explain the disparity between the funding of your solid rocket program for $3 million and your liquid rocket program for $68 million?"

"Don't solid-rocket proponents, with some glee, point out to you liquid-rocket men that when you want something safe to escape you use a solid-propelled rocket?"

". . . if the Navy had not developed the Polaris, it is very possible that we would never have had the Minuteman; isn't that so?"

"Dr. von Braun . . . would you say that your reservations (about big solid propellant boosters) are largely due to the fact that you are, after all, a liquid propulsion expert and know little about solids?"

On the receiving end were Dr. Wernher von Braun, Director Marshall Space Flight Center, NASA; and Major General Don R. Ostrander, USAF, Director Launch Vehicle Programs, NASA.

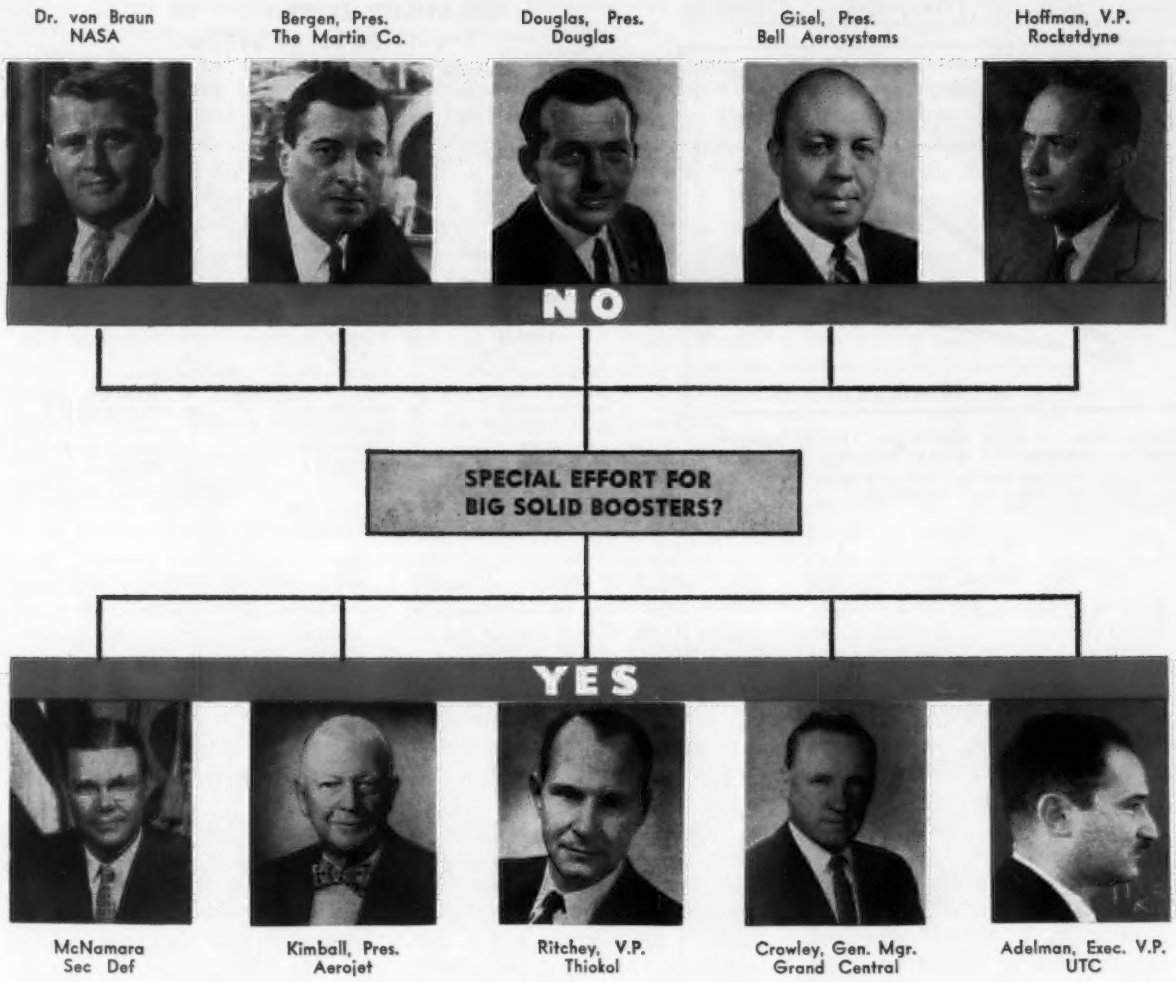
The Overton Brooks committee was probing top management in NASA and industry about why we had not closed the space-booster gap. Why had NASA, which has charge of big-booster development practically ignored solids in the face of claims that a multi-million pound thrust booster could be built in 18 months?

Solid-rocket proponents had already told Congress that solid-rockets were in fact: cheaper, simpler, more reliable, easier to build, easier to transport, capable of giving more pounds of propellant for every pound of gross weight, and more capable of closing the booster gap.

State of Mind—One solids-man, Barnet Adleman of United Aircraft had said, ". . . the state-of-the-art of solid propellant rockets has often been the state of the mind. In fact, it has been the state of the mind of people who know very little about solid-propellant rockets" . . . (however) "there are dedicated people in NASA who understand the problem."

Is NASA dragging its feet in solid propellant rockets? These are some of the views expressed by Gen. Ostrander and Dr. von Braun.

Price—NASA equates the cost of a booster to the expense incurred in putting a pound of payload in orbit. This is because we are now



thinking in terms of orbiting 45,000 lb payloads and accelerating up to 15,000 lb to escape speed.

Gen. Ostrander says, ". . . with our present family of IRBM or ICBM-boosted space vehicles, cost runs anywhere between $10,000 and $100,000 per pound of payload in orbit. By 1967-68 Saturn will have reduced the space transportation cost to less than $500 per pound for low orbits and $3000 per pound for soft lunar landings. . . . These figures are based on a non-recoverable Saturn C-2. If we succeed in recovering the first stage, and it is profitable to reuse it, the cost might come down to $100 per pound for Earth-orbit.

"We are not satisfied with this figure. We are striving to chop this cost further. With the recovery of all stages, we have reason to expect that cost can be reduced to as little as $25 to $50 per lb payload.

"Applying the fully reusable concept to lunar operations would improve cost by a factor of 25 to 50." The cost of transporting cargo to the moon would drop from $3000 per pound, to $100 to $200 per pound. The cost of transporting personnel, round-trip, would drop from $30 million to $600,000 per person.

Gen. Ostrander says further, "this difference means that $1 billion spent in 1975 will provide a 200-man base on moon with the reusable concept or a 10-man station with a non-reusable concept."

Dr. Ritchey of Thiokol claims that the clustered solid rocket has the following capabilities with a throw-away case: "Orbit capability of 3,700 to 2,100,000 lbs can be obtained and escape payloads of 1,000 to 300,000 pounds can be achieved. These extensive and necesssary capabilities can be attained for as little as $107 per pound of payload in orbit and $321 per pound of payload to escape."

Recoverable Saturn—NASA is concentrating its effort on the recoverable Saturn. The whole program is now centered on the "Paraglider" or "Rogallo Glider." Parachute techniques have been abandoned. There is an "aggressive" wind tunnel program underway at Langley to prove this concept. Two companies have study contracts, Ryan and North American Aviation.

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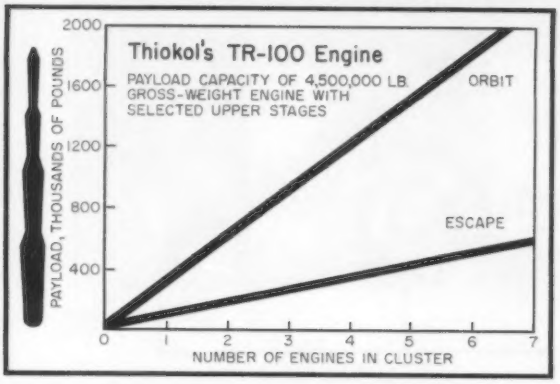

Thiokol Chemical Corp. claims that TR-100 booster could be available for orbital missions by 1966. Planetary reconnaissance and planetary landings are within the same time schedule.

RELIABILITY EXPERIENCE OF 59 LIQUID BOOSTER SYSTEMS

53 Booster Successes
6 Booster Failures

34 Successful Satellites
19 Upper Stage Failures

1	EXPLORER I	20	DISCOVERER X +	40	PROJECT SCORE
2	EXPLORER II ●	21	DISCOVERER XI	41	TRANSIT IA ●
3	EXPLORER III	22	DISCOVERER XII ●	42	TRANSIT IB
4	EXPLORER IV	23	DISCOVERER XIII	43	TRANSIT IIA (NRL)
5	EXPLORER V ●	24	DISCOVERER XIV	44	IONOSPHERE BEACON
6	EXPLORER VI	25	DISCOVERER XV	45	TRANSIT IIIA +
7	EXPLORER VII	26	DISCOVERER XVI ●	46	TRANSIT 3B
8	EXPLORER VIII	27	DISCOVERER XVII	47	ATLAS ABLE IV ●
9	EXPLORER +	28	DISCOVERER XVIII	48	ATLAS ABLE 5A ●
10	EXPLORER RADIATION ●	29	DISCOVERER XIX	49	ATLAS ABLE 5B ●
11	DISCOVERER I	30	DISCOVERER XX	50	MIDAS I ●
12	DISCOVERER II	31	DISCOVERER XXI	51	MIDAS II
13	DISCOVERER III ●	32	PROJECT ABLE I +	52	TIROS I
14	DISCOVERER IV ●	33	PIONEER I ●	53	TIROS II
15	DISCOVERER V	34	PIONEER II ●	54	SAMOS I ●
16	DISCOVERER VI	35	PIONEER III ●	55	SAMOS II
17	DISCOVERER VII	36	PIONEER IV	56	PROJECT ECHO ●
18	DISCOVERER VIII	37	PIONEER V	57	ECHO I
19	DISCOVERER IX +	38	BEACON I ●	58	COURIER IA +
		39	BEACON II ●	59	COURIER IB

● Indicates Upper System Failures

+ Indicates Booster System Failures

Dr. von Braun, says with regard to cost, ". . . you need an additional investment to develop recovery techniques. You begin saving money, according to our analysis after about 50 firings."

There is no argument between solid and liquid experts on the matter of recovery. Both agree it would save money. But, Gen. Ostrander says, "it is most unlikely that recovery will be applied to solid stages since most of the cost of solid stages is in the propellant, whereas most of the cost of liquid stages is in the hardware."

Propellant by the Pound—There is argument over the purported economies of solids. Dr. von Braun says, ". . . about the propellant price, the most popular solid propellant available today is called polyurethane. This costs approximately $1 per pound. A liquid propellant mixture is kerosene and LO_2. It costs about 5 cents a pound.

"There is no question that pound per pound, for propellant alone, the liquid rocket is far more economical" . . . "I would say that the hardware . . . the nonpropellant portion of the solid rocket is simpler and cheaper than the liquid rocket."

Dr. Ritchey (Thiokol) disagrees with Dr. von Braun. "Independent studies have shown that a booster (multi-million pound solid) can now be provided at a cost well under $2 per pound gross weight. The propellant ingredients themselves, comprising 85 to 90 per cent of the vehicle's weight, can be purchased at an average of 40 cents per pound . . . experience and manufacturing economics could probably reduce overall engine costs to around half the $2 per pound figure."

Concerning the recent flood of claims that a solid rocket even now could beat Saturn to the punch Dr. von Braun told Congress: "My skepticism if you want to call it that, with respect to a crash program for a very large solid booster is mainly based on the following:

"I am not aware of any procedure which permits us to simply scale up from the little solid rocket to the big solid rocket. For example, testing a very large solid rocket to insure that there are no cracks in the grain is still something that must be developed.

". . . These things can be done, but they are time consuming. And they are money consuming. We have to go through the same painful process of building up this technology that we went through with liquid rockets.

"I think the fundamental difference between the opinions presented by many solid-rocket people and (NASA's) is time. They say they can build it in 18 months. We don't doubt that. But after building it they still have to test 50 to 100 of them, and develop inspection and check-out procedures. This is not cheaper than doing it with liquids."

Gen. Ostrander joins von Braun by echoing, "at 18 months, a solid rocket (of 3 to 4 million lb thrust) is not a useful stage. It is a basic motor that must be integrated into a useful stage."

Specific Impulse — Much has been said about specific impulse being higher in liquid fuels than in solids. This is what the NASA organization says: Gen. Ostrander—". . . an RP-LOX system under optimum conditions would give us an Isp of 260 sec. This is in the order of 6 per cent greater than the present solid Isp of 245 sec. If we consider specific impulse alone this would give us some 6 per cent greater payload." Von Braun—"It is feasible to come up with solid propellants with a specific impulse as high as 300 in solids. However, you sacrifice a good portion of that potential chemical energy to get the desired physical properties for the solid propellant, so that, for example, during high pressure combustion, chunks wouldn't be torn out of the grain and blown out the nozzle.

"It is for this reason that you cannot really economically exceed a specific impulse of about 240 in solid rockets."

Dr. von Braun explains further that in Polaris where there is ample

electric power from the nuclear powerplant in the submarine to air condition the missiles at all times, it has been possible to gain 20 sec, for a 260-sec specific impulse.

The solid propellant experts say specific impulse is not the whole story. They say that the plumbing equipment on a liquid engine constitutes so much dead weight. The ratio of propellant to gross weight is not as high as it is in solid rockets where there is less plumbing. They call this the mass ratio. Dr. L. G. Bonner, director of development at Hercules, says, "a rule of thumb in the current state of the art is that it takes 60 lb of propellant to orbit one pound of payload. An increase of one point in mass fraction can increase payload by 22 lb. A one point increase in specific impulse will increase payload only 5 lb."

DOD Action—In June 1961, Defense Secretary Robert S. McNamara told the House Appropriations committee there are plans for AF to embark on a large-solid-booster program. Its initial funding will be $62 million, total cost is estimated at $500 million. Four contractors will be invited to submit proposals. Two will be selected for preliminary work. The field will then be narrowed to one contractor. Congress has still to make the money available.

The booster has been referred to as a solid Nova. This decision clearly puts AF back in the big booster business once monopolized by NASA. However, work on the solid Nova will still be to NASA specifications. McNamara is in effect crashing through the red tape and hopelessly entangled conflict of opinion to get the big solid booster program underway.

Industry Views—Who will be selected for the work? This should be interesting in light of expressed opinions on solid booster: Here is what industry said in March 1961.

The Martin Co.; William Bergen, President: "Theories abound today to suggest the excellent properties of many approaches to the booster problem . . . theories are statements of hope . . . we should concentrate first on the liquid booster for large, first-stage engines. If there is time, energy, and money left over, we should apply it to the solid booster."

Rocketdyne Div., NAA; S. K. Hoffman, Vice President: "Solid-propellant engines or boosters have a sound role for one-shot, small to nominal payload missions. Liquid-propellant engines must provide the power for more ambitious missions."

Aerojet - General Corp.; Dan Kimball, President: "There are certain things you can do with solids; certain things you can do with liquids in long-range exploration. The segmented solid wouldn't be superior to the liquid booster. It would be simpler and cheaper."

Thiokol Chemical Corp.; Dr. Harold W. Ritchey, Vice President in charge of Rocket Operations: "The highest thrust rocket engine flown in this country is a solid rocket engine. It is the first stage of the Nike Zeus. It develops in the order of a half million pounds of thrust out of a single chamber . . . the most direct, quickest, and most economical approach for obtaining high-thrust engines in quantity for first and second-stage applications is through the development of solid-propellant engines."

United Technology Corp., Div. United Aircraft; Barnet Adelman, Exec. Vice President: ". . . within 18 months we can be firing 2 to 3 million pound thrust boosters (segmented solids) and by 1964, using those engines. We can be flying payloads in the range of 35,000 lb."

Chance Vought Corp. (Ling-Temco-Vought Inc.); J. R. Clark, General Mgr., Astronautics Div.: "There is no clear-cut choice between large-solid or large-liquid boosters at the present time, and therefore, we recommend that both concepts be supported at a higher level with R&D funds."

Bell Aerosystems Co.; William G. Gisel, President: "Many irresponsible statements have been made concerning the high reliability and low cost of solid propellant rockets in comparison with liquids which simply are not in accordance with the facts."

Grand Central Rocket Co.; Cledo Brunetti, President: "Reliability is the key to project success. Since solid rocket motors are more reliable than liquid rocket motors, there is a greater probability of success if solid rocket motors are used."

Douglas Aircraft; Donald W. Douglas, Jr., President: ". . . while solid propellants have unique advantages, particularly in weapons where storability and instant response are prime requirements, it is questionable if these features are of sufficient importance in the application of large space boosters to justify the development of such a vehicle."

The Boeing Co.; William M. Allen, President: ". . . The Boeing Co. believes that the launch weight considerations currently tend to give the liquid systems the edge. However, it is not possible to draw clear conclusions, because factual analyses have not been accomplished on a sufficiently common basis . . ."

SOLIDS vs. LIQUIDS Grand Central Rocket Co.	Saturn S-I	Segmented Solid Cluster of Three
Development cost, including 10 flight boosters ($ millions)	487	43
Development time (years)	6	3
Payload pounds (using H_2-O_2 upper stages in orbit)	48,000	60,000
Immediate growth potential (percent total impulse)	None	*66
Cost—dollars per lb in orbit, 100 flights, 300-mi orbit	743	361

* The addition of 2 more segments to each of the 3 motors provides an immediate growth potential of 66 per cent.

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YOU CAN GET

More Reliable Electronics

- *Air Force is clamping new controls on electronic-systems contractors.*
- *AGREE program forces management to plan for reliability in design phase.*
- *Subs must supply proof-tested components to primes.*
- *Primes must "monitor" reliability programs of component suppliers.*
- *RCA has upped electronics longevity 62 per cent in Bomarc by applying AGREE.*

• Here's How . . .

by Paul Jay Goldin, Manager
Statistical Quality Control
Airborne Systems Div., RCA

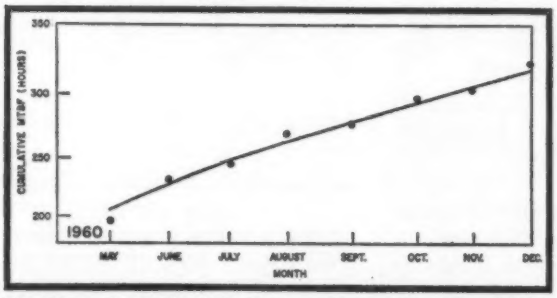
New reliability controls are being clamped on electronic-systems contractors by Air Force. They are called the AGREE requirements.

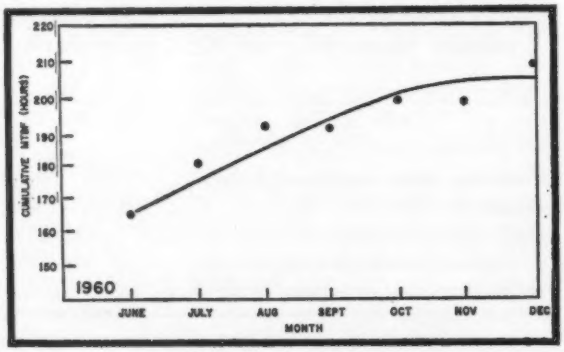
Minimum operating life of each piece of electronics is fixed by Air Force at the time a contract is issued. The contractor must agree to meet these MTBF (Mean Time Between Failure) demands. And, he must show proof that his product does in fact, meet these longevity demands before Air Force will take initial delivery. The contractor then operates on a monthly basis, qualifying each month's output before Air Force accepts that lot.

Monthly Qualifications—AGREE requirements are based on the Task Group 3 section of the Advisory Group on the Reliability of Electronic Equipment document. Contractors must set up organized plans to assure that the design-development - production of their equipment will pass AGREE tests. Failure to meet initial or monthly qualification can cause severe hardship on the contractor. Schedules will be missed. Billings will be lost. Costly rework and retest will result at the contractor's expense.

Organizing for AGREE—How can a company cope with, organize for, and learn from AGREE? RCA has done all three.

Experience with AGREE at RCA has resulted in many reappraisals of how to manage the engineering, and manufacturing sections. Where there had been doubt





Electronic longevity has increased at RCA since AGREE concept was adopted. Growth curve for (Bomarc) ARR-61 is shown in Fig. 1 (above). Fig. 2 (right) is ARR-60 curve.

AGREE DECISION-MAKING TEAM

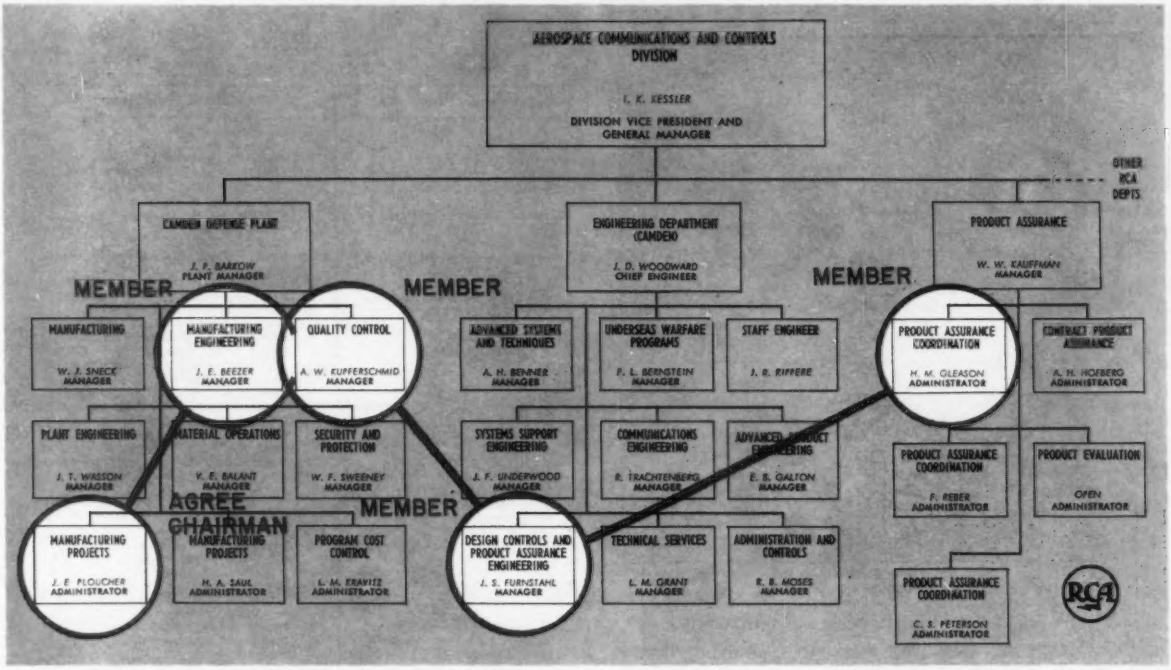


Fig. 3. AGREE policies and decisions are made in RCA by a special committee of managers. They meet at closely scheduled intervals at start of a project, later meet only on call to solve specific problems. Action decisions are passed directly to affected design, production, or procurement sections to speed results.

in AGREE, there is now confidence that it can be used as an effective means of improving reliability. RCA has compressed into 3 months the process and design changes that stretched over one or two years on non-AGREE equipment.

RCA got its feet wet with AGREE on Airborne Time Division Data Link systems used in Bomarc and F-100 Super-Sabres. The equipment provides high-speed communication and control information for intercept, tactical control, and traffic control. Progress made with this equipment is shown in Fig. 1 and Fig. 2. Other RCA equipment now being produced to AGREE standards includes:

(1) AN/ALR-19 Countermeasures Receiving Set.

(2) DATS Dynamic Accuracy Test Set.

(3) AN/TSM (22, 26, 28 & 29) Data Line Test Sets.

(4) Minuteman Sensitive Command Network (Form of AGREE).

When RCA contracturally committed itself to minimum MTBFs, it realized that normal quality control methods would not be adequate.

What AGREE demands is an extremely tight system to control the processes that span procurement of vendor parts through field installation of final equipment. This process-control system must have a three-fold objective:

- Push the debugging stage as far back in the assembly and test phase as possible.
- Reduce the influence of the human factor.
- Assure the customer (AF) and RCA that each system, AGREE tested or not, meets the contractural MTBF.

Table 1 shows RCA's pre-AGREE and present control programs.

Until the advent of AGREE, review and acceptance of engineering-built models was limited to test and inspection of the final product. It didn't take long to realize that many production problems could be eliminated by enforcing quality control on Engineering. Quality and Process personnel were therefore assigned to Engineering at the design and prototype stages. These people were made responsible for the compatibility of mechanical designs with military specifications, and assembly techniques. The transitition from prototype to factory production could then be made smoothly. This integrated program has considerably reduced the number of Change Notices on AGREE Electronic hardware.

Burn-In—Many meetings and discussions were held prior to production. The managers who participated are shown in Fig. 3.

It was concluded that one of the two most important steps manufacturing could take would be to debug AGREE-systems as far back in the production cycle as possible. So, exhaustive environment debugging tests were enforced at selected component, sub-assembly, and black - box levels. Previous method was to debug only black boxes and systems under ambient bench test conditions.

Now, all suppliers who build major assemblies are required to burn-in their units for given periods

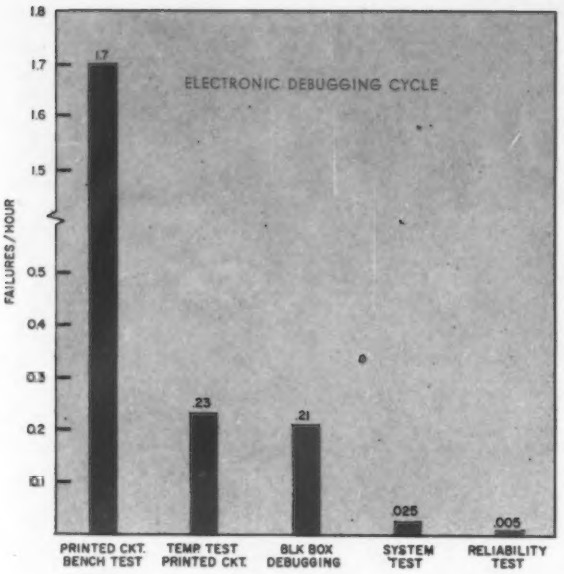


Fig. 4. Results of debugging equipment early in design phase can be seen from small number of failures occurring in final test.

TABLE I
RCA PROCESS CONTROLS PRE-AGREE & PRESENT

Normal Program	AGREE Program
1. Contractual Review.	1. Contractual Review.
2. Design Review.	2. Design Review.
3. Reliability Predictions.	3. Reliability Predictions.
4. Quality Control Acceptance of Engineering Models.	4. * Quality Control Technicians and Inspectors assigned to Engineering. Quality Control Acceptance of Engineering Models.
5. Award of Purchase Orders.	5. * Pre-purchase Order Award Surveys. * Vendor Ratings. Award of Purchase Orders.
6. Supplier Quality Field Coverage.	6. Supplier Quality Field Coverage. * Suppliers Burn-in Black Boxes. * Purchase Spec. Requires MTBF Demo.
7. Purchased Material Inspection.	7. Purchased Material Inspection.
8. Printed Circuit Assembly and Test.	8. Printed Circuit Assembly and Test. * Printed Circuit Burn-In. * Printed Circuit Environmental Tests.
9. Assembly and Wiring.	9. * Visual Acuity, Color Discrimination, and Manual Dexterity tests for operators. * New wiring, soldering techniques. * Controlled atmosphere for Assembly. * Increased Programmed Automatic Circuit Checkers.
10. Black Box Bench Tests.	10. Black Box Bench Tests * Black Box Burn-In Tests employing variable combinations of environments, such as Temperature and Vibration.
11. System Test.	11. System Test.
12. System Burn-In.	12. System Reliability Tests (AGREE).
13. Final Acceptance.	13. Final Acceptance.
14. Packing and Shipping.	14. Packing and Shipping.
15. Lab. Analysis of Rep. Failures.	15. * Lab. Analysis of ALL Failures.
16. — — — — —	16. * Return of Failed Parts to Suppliers for Corrective Action.
17. Data Reporting.	17. Data Reporting. * Special AGREE Forms and Tags. * Engineering Failure Analysis.
18. Training Programs and Instruction. Testers and Test Supervision. Inspectors. Assembly Operators.	18. Training Programs and Instruction. Testers and Test Supervision. Inspectors.
	* Management Function.

under the same environmental conditions imposed on RCA built units. All printed boards are subjected to a dynamic bench test at room temperature, at extreme temperature, and at room temperature again. Each board thus receives about 5 hr of testing. Each black box is tested for 48 hr under the same environment as the overall system encounters in AGREE tests. This debugging procedure sees to it that all black boxes, sub-assemblies, and components get the same environment stress whether they are sampled in AGREE or not. (Results of the complete debugging cycle are shown in Fig. 4).

Assembly—A tight control on assembly processes and methods was considered by management to be just as important as pushing back the debugging phase.

Added to normal controls were special tests for assembly operators, a controlled assembly environment, new soldering methods, laboratory analysis of **all** failures, special failure reporting forms, and a closed information loop involving Factory and Engineering Quality Control.

All assembly operators are now required to pass a visual acuity, color discrimination, and manual dexterity test, prior to being assigned an AGREE program. Operators are equipped with thermostat controlled soldering irons for normal soldering. Resistance soldering irons are used for soldering in restricted areas.

Wiring and soldering techniques have been revised to keep the possibility of no-solder joints and broken strands to a minimum. Specially designed cardboard frames that support cables and prevent them from being flexed during assembly and handling were introduced and have been very successful in preventing broken strands. Thermal stripping of wire is being used in many areas to prevent nicking of wire strands and subsequent breakage.

Failure Analysis — A major shortcoming of many quality programs is the lack of accurate failure reporting and analysis. Test personnel may treat failure reports, and data recording, as secondary tasks. This approach cannot be tolerated where AGREE is concerned. Failure reporting and analysis provide the basis for evaluating process controls.

The AGREE document spells out the type of forms that must be maintained during the reliability and longevity tests, and the failed part analysis required. The information is processed into six forms, the most important of which is the Failure Report. This report is a master which must be completed for every failure. The tester and his supervisor complete their section. If a component or sub-assembly is involved they send the defective part and the failure master to the Quality Control Laboratory. The Quality Control Laboratory analyzes the part for mechanism of failure and reports its findings.

If the responsibility for failure is a supplier's, the part and a failure report copy are sent to the supplier for his analysis and corrective action. If the responsibility is RCA's, corrective action is taken by the responsible assembly or test area. Every failure report is sent to Reliability and Design Engineering for

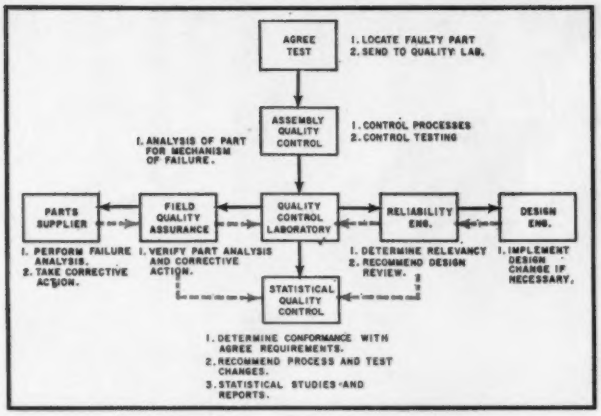

AGREE TEST
1. LOCATE FAULTY PART
2. SEND TO QUALITY LAB.
ASSEMBLY QUALITY CONTROL
1. CONTROL PROCESSES
2. CONTROL TESTING
1. ANALYSIS OF PART FOR MECHANISM OF FAILURE.
PARTS SUPPLIER
FIELD QUALITY ASSURANCE
QUALITY CONTROL LABORATORY
RELIABILITY ENG.
DESIGN ENG.
1. PERFORM FAILURE ANALYSIS.
2. TAKE CORRECTIVE ACTION.
1. VERIFY PART ANALYSIS AND CORRECTIVE ACTION.
1. DETERMINE RELEVANCY
2. RECOMMEND DESIGN REVIEW.
1. IMPLEMENT DESIGN CHANGE IF NECESSARY.
STATISTICAL QUALITY CONTROL
1. DETERMINE CONFORMANCE WITH AGREE REQUIREMENTS.
2. RECOMMEND PROCESS AND TEST CHANGES.
3. STATISTICAL STUDIES AND REPORTS.

Fig. 5. Failure reporting is key to success in AGREE. This is the cycle used at RCA.

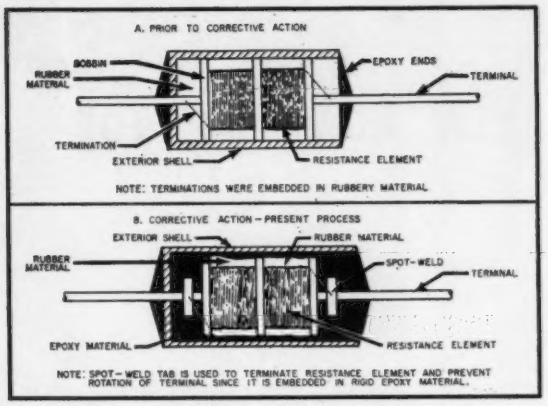


Fig. 6. AGREE fix is illustrated in this resistor cutaway. Prime contractor spotted the trouble.

review and recommendation. Corrective action from Engineering takes the form of Change Notices. This entire failure reporting cycle is shown in Fig. 5.

Although failure reporting and analysis at the reliability test phase is needed from the standpoint of determining corrective action, it is actually **after** the fact. The report information can be used to prove whether or not equipment met the MTBF requirement. It can also be used to take action to prevent similar failures in following months. But it cannot prevent the manufacturing activity from experiencing an AGREE reject decision should too many failures occur.

To provide control and corrective action within each monthly AGREE demonstration, it is necessary to analyze every part failure from printed circuit testing up to AGREE system testing. Although this is a drastic change from the normal procedure of analyzing only repetitive failures, it has played a major role in helping RCA to fulfill contractual MTBF requirements.

Results of AGREE Testing—After three years experience with AGREE, 86 ARR-61 systems and 77 ARR-60 systems (both for the F-100) had undergone reliability tests. Fig. 1 and 2 depict the progress made in meeting or exceeding contractual requirements. The DRR-1 (used in Bomarc) system is not shown. This equipment's MTBF has been 20 times greater than required since the start of production. Except for the ARR-60, the equipments started out meeting the contractual MTBF requirements. The ARR-60 had experienced an AGREE Pre-Production reject decision due to a combination of design problems, plus assembly and test inexperience with the product. It should be realized that the AGREE test is extremely responsive to problem areas, and one or two problems of a repetitive nature can very quickly cause a reject decision. Fortunately, the descriptive and laboratory analysis that was performed on each failure provided sufficient information so that corrective action could be implemented quickly. The lack of trouble with the ARR-61 and DRR-1 reflects the use of ARR-60 experience to correct potential trouble spots in those systems prior to subjecting them to AGREE.

Failure Examples—One of the first AGREE failures experienced was a film resistor that had cracked open. Analysis of the part indicated that during prolonged periods of temperature cycling, a reaction took place between the resistor's film coating and the conformal coating used to encapsulate the printed board. A combined effort by the supplier and RCA Engineering resulted in a new resistor coating which eliminated the problem. The important point of this example, and similar ones, is that without the pre-AGREE and AGREE environmental stressing, this condition may not have become known until failures occurred in the field. Then costly and time-consuming retrofit program would have been necessary. By identifying the problem in the factory, corrective action could be made prior to shipment of systems. The above example, however, counted as a failure with respect to the AGREE accept-reject criteria.

A second example illustrates how analysis prior to the AGREE test can prevent AGREE failures. Analysis of a wire wound resistor indicated that the leads were insecurely terminated in the rubber material of the resistor's interior. This allowed the lead to rotate, breaking the contact internally. Based on this analysis, 2066 resistors in stock and on printed boards were X-rayed. The findings indicated that 50 resistors had the internal contact broken. The resistors were returned to our supplier for their corrective action. Similar failure analyses have resulted in many potential AGREE failures being weeded out prior to the AGREE test.

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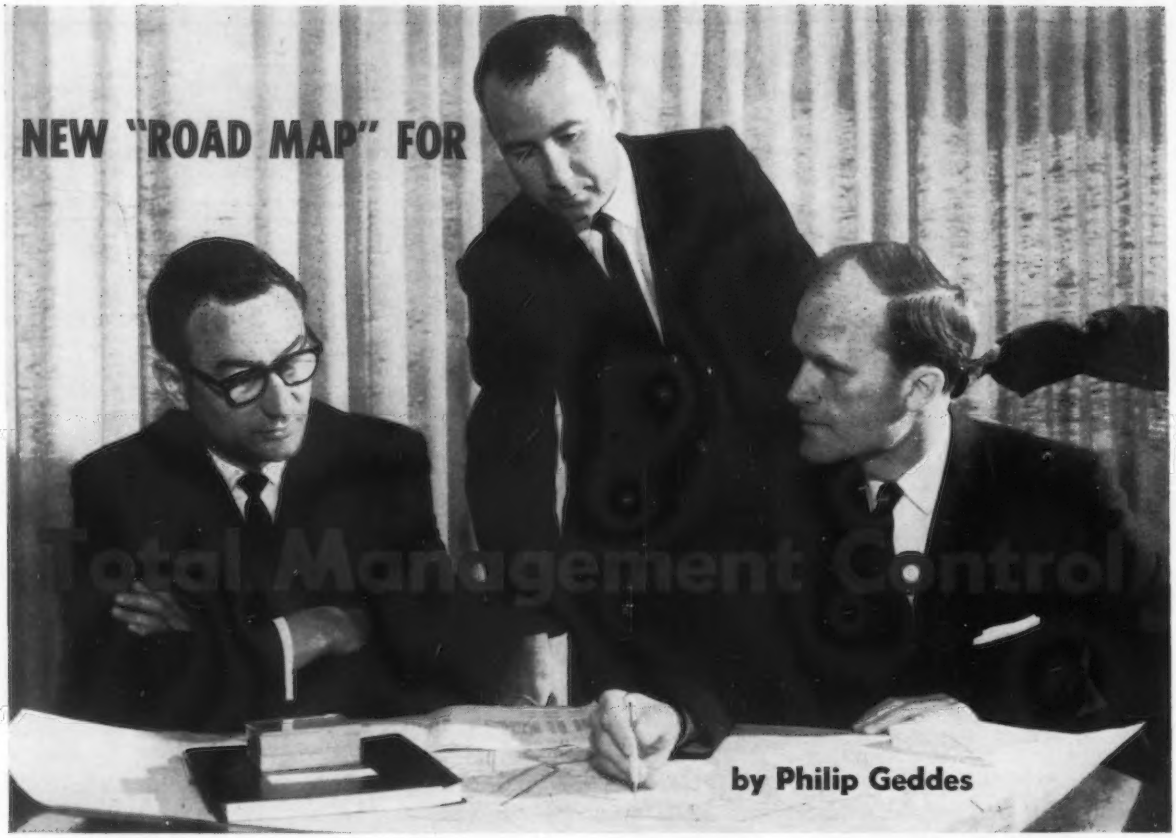
NEW "ROAD MAP" FOR Total Management Control

by Philip Geddes



Schedule Visibility System is discussed by Aeronutronic Technical Staff (from left): H. T. Larson, manager, Electronics & Program Control Systems; J. D. Tuttle, Program Analysis; and Dr. E. H. Krause, Technical Staff director.

Management must be kept constantly aware of four factors to totally control R&D contract programming. They are:

- Technical proficiency
- Scheduling
- Cost
- Customer satisfaction

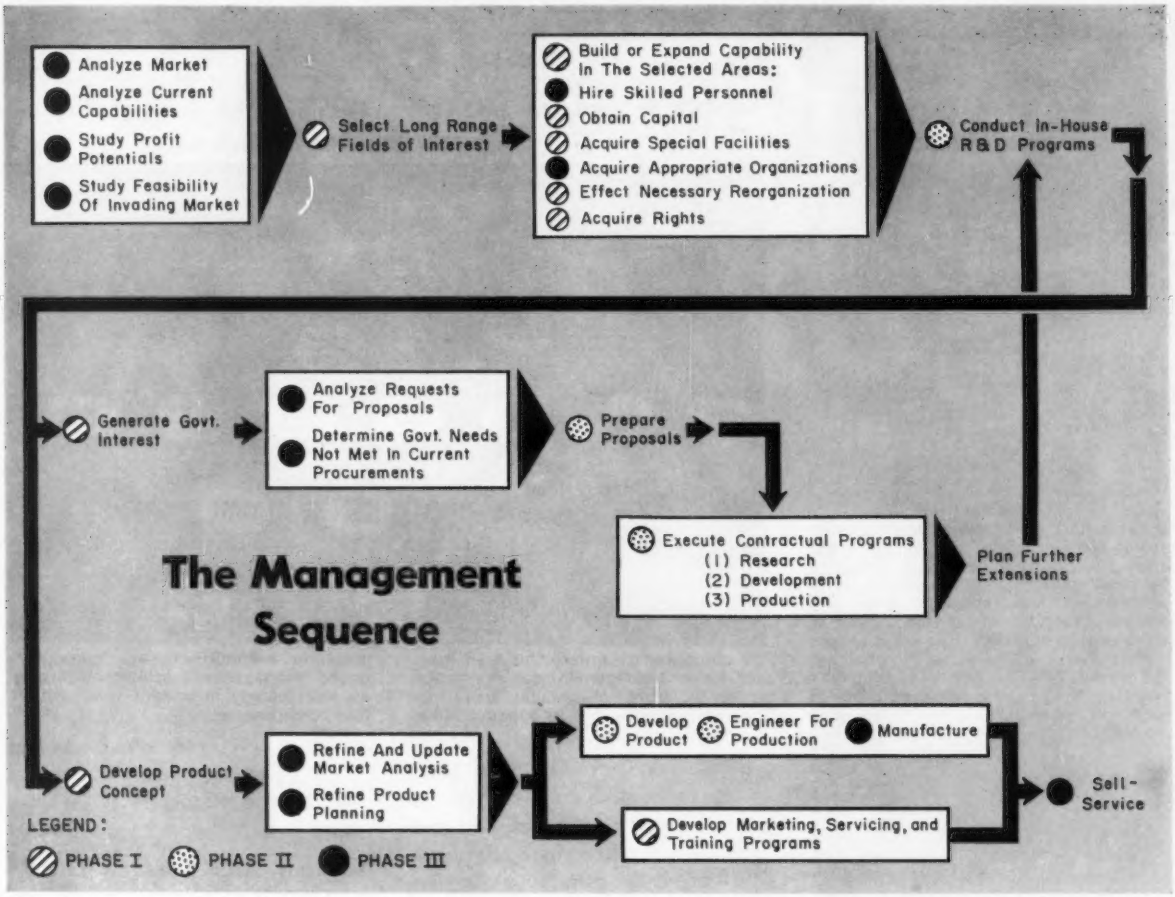
Systems for scheduling and keeping up with costs already exist. But, they are still not working properly. A new system is required which will incorporate all four stages and will carry them through proposal — contract — production. Not even PERT and PEP operate in the production area.

Aeronutronic Div. of Ford Motor Co. is studying such a total system. The conceptual planning will be finished by the end of this year. When it will be fully incorporated is unknown.*

An adaptation of PERT (Program Evaluation and Review Technique) is already coming into effect at Aeronutronic. Called Schedule Visibility System (SVS) it provides improved scheduling and project analysis but is only phase one of the overall scheme for the future.

SVS in effect gives managers a "road map" which tells them when decisions must be made and what alternatives are available. On the visual display of computer processed information, a network of circles and lines record and trace the interrelationships of project events and tasks. Circles represent events and arrows, tasks which lead to events. Management can choose an alternative programming route when an event is unattainable or undesirable. In essence, SVS throws up red flags and points out trouble areas as they occur according to a predetermined mechanism. Other required management control devices using computers for cost control and random access to data are not available (even with SVS) to meet daily needs in planning tasks to milestones and sets of criteria.

Aeronutronic is intent on establishing a control which will ensure them that as they move into a task at any given time they will be in line with the contractual cost-plan. The four main factors cited previously must be observed to do this. Reasons for desiring a management control device is inherent in the nature of Aeronutronic business. Dr. Krause, Director of Technical Staff, says that the company inherits the cost consciousness of the automobile industry in a business which until recently was content to operate on cost-plus-fixed-fee contracts. These contracts lack an incentive to know costs. Now aerospace companies such as Aeronutronic must be dynamic in their



long-range planning and must do research in the right areas or lose important markets. Researching a product area is not good business unless there is a market for the product. Cost of research is always very high, to it must be added development and marketing costs.

Program—There are three major steps in implementing the overall program. (See chart above.)

Phase I. This part of the program is completed and in operation at Aeronutronic.

- Cost Control System
- Schedule Visibility System

both now operating independently

Phase II. Now under way. Cost schedule, technical performance, and customer satisfaction are to be integrated into an overall production control system.

In this phase, criteria of performance, and systems to measure technical performance and customer satisfaction must be added.

Under examination is a modified system of SVS applied to the manufacturing area.

Phase III. The ultimate program, which will be an overall system based on revisions and replacements in the existing methods.

In this phase, increased emphasis will be placed on advanced analysis techniques to contribute additional measurement and control tools to management. Examples of the types of analyses which can be performed at the project level after Phase III include:

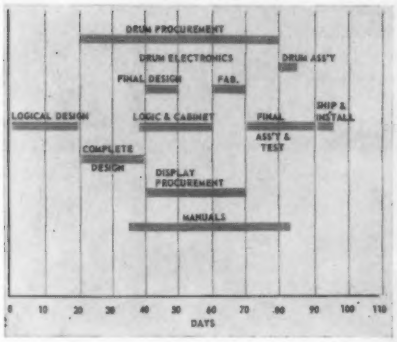
- Cost as a function of Delivery Date
- Cost as a function of Method of Sequencing Program Elements
- Cost as a function of Performance Goals
- Cost of R&D Program as a function of Production Cost
- Resource Requirements as a function of Delivery Dates
- Resource Requirements as a function of Performance
- Reliability Predictions

Aeronutronic Technical Staff members, Harry T. Larson and John D. Tuttle, under Dr. Krause are responsible for studying and constructing a workable system. They work under a clear organization and management philosophy, but even the best of intentions will not establish anything. Certain objectives and guidelines such as the following have to be held in mind and built into the system:

- Clearly defined single point of responsibility.
- Authority commensurate with responsibility.
- Physical and Personnel Resources needed to carry out responsibilities.
- Strict Accountability for execution.

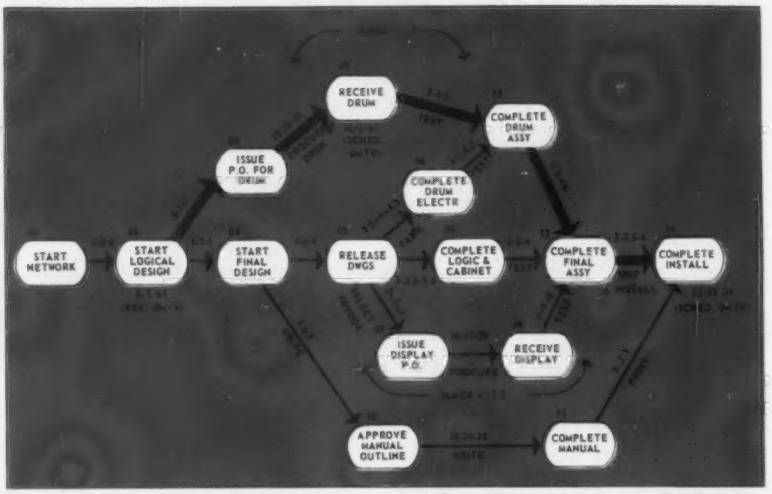
. . . continued on next page

OLD METHOD



Old method of showing time phasing and project progress was to use a bar chart. New method at right is Aeroneutonic's "road map" to successful management. Arrows represent tasks and circles represent events. Slack time is expressed in numbers, i.e., —2.3 means that task time would delay the program 2.3 weeks. A + 2.3 indicates that task time is that many weeks ahead of schedule. Aeronutronic uses an IBM 709 computer to update the road map each week. Management can reallocate resources from plus-slack areas to those with minus-slack to beat schedule problems. Aeronutronic says "computer-based management science will play an increasingly important role" within their company.

NEW METHOD



- Independent channel for Continuing Evaluation.

Review of Objectives:

- To insure that the operations of the division have uniform procedures for providing line and staff managers with frequent, up-to-date reports on the progress on all projects within their jurisdiction.
- To insure that these reports state clearly progress in relation to performance in areas of technical quality, time schedule, costs, and customer acceptance.
- To insure that the systems provide a quick reaction to impending or actual difficulties.

Benefits:

- Clear understanding of status.
- Critical areas highlighted.
- Information available as a basis for planning for action.

Means:

- Lower Costs
- Better Use of Resources
- Higher Quality Products
- Better Customer Acceptance

Aeronutronic planners say there are two basic reasons why the Aerospace Industry has not accepted what is required in this type of system. The first is that Planning and Research analysis is of recent origin. Secondly, the technology has moved so quickly and more into Cost-Plus-Fixed-Fee arrangements. The overall result is that in R&D, the industry has proceeded as best it could and took whatever came out.

There are some basic problems in establishing the Aeronutronic "Integrated Program Visibility" system. Such things as common measures of performance which mean the same thing to all participants must be found. Getting data into a system and then displaying the results are basic difficulties. In this regard, Aeronutronic's work on the battlefield control system for the Army, ARTOC (Army Technical Operations Central) points the way to the solution for the data input/display problem. The highly skilled technical staff to man the system must be found. These people must have a high enough degree of technical proficiency to make judgments on technical performance and progress: their judgments will form basis of inputs into the machine system.

Cost of an "Integrated" system will be high. PERT in Dr. Krause's opinion was developed on a project where cost was no object. He added that the cost was well worth it. The Aeronutronic system he concludes will also be well worth it.

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HUMAN ERRORS in rocket testing

- *Twenty to fifty per cent of rocket-test failures can be attributed directly to human error.*

- *Findings based on Titan first and second stages reveal classifiable human failures in:*

  (1) Installation of components or omissions

  (2) Improper use of switches

  (3) Faulty settings and wiring, and improper checkout

  (4) Fueling without adequate decontamination procedure

  (5) Repairs of sub-standard quality on components

by Lane B. Blank, and **Gustavus S. Miller, Jr.**
Liquid Rocket Plant, Aerojet—General Corp.

From 20 to 50 per cent of rocket test failures may be directly attributed to human error.

The categories of errors that cause the spectacular types of aborted launchings include:

(I) **Installation**
- A. Partial or incorrect installation
- B. Omission of component
- C. Wrong component installed

(II) **Use**
- A. Improper use of switches
- B. Improper use of items
- C. Faulty judgment

(III) **Settings and Wiring**
- A. Poor control settings
- B. Faulty test stand wiring
- C. Improper checkout

(IV) **Fueling**
- A. Poor bleed
- B. Insufficient loading
- C. Poor decontamination procedure

(V) **Repairs**
- A. Faulty or previously-damaged part
- B. Poor repairs on component or part

These findings are based on Aerojet-General Corp. reports on Titan liquid-propulsion systems tested during 1959.

Accompanying bar chart reflects the percentages of the classes of human errors reported for the two Titan stages. Chart shows that the classes relating to partial or incorrect installation and poor control-settings contained the highest percentages of human failure reports; while, the least-frequently reported classes were faulty judgment and poor repairs. It should be noted at this point, however, that the number of errors reported in second-stage testing was nearly three times that in first stage.

Each pair of classes was treated, in turn, for the significance of the difference of the percentages of all human errors for the particular stage. For each corresponding class the difference between the percentages and the standard error of that difference were determined, and from these items the critical ratio was computed. It can be seen in the table that for only one comparison (class (2) B, "improper use of items") was the critical ratio sufficiently large to warrant the conclusion of significant difference between the two stages. The ratios of difference-to-standard error ranged from 0.302 to 2.015; the latter being only sufficient to reject the null hypothesis at the

10 per cent level. It might be noted, also, that the actual differences between percentages ranged from 0.96 to 12.50.

Conclusions Drawn—The principal conclusions derived from this study are as follows:

- Human causes of rocket test failure are classifiable.
- For the data studied, distributions of human errors do not differ significantly between the two stages of the Titan system.
- From the gathered data, with special attention to those classes of error most frequently reported, it may be gathered that future preventive measures should focus particularly upon the elimination of partial or incorrect installation, faulty control settings, and insufficient loading of propellants.
- It is evident that not all malfunctions officially classified as such were actually human-initiated; however, it is likely that a number of human errors escaped proper classification.

Implications—The testing of large rocket engines and their components is a complicated operation. This involves an intimate knowledge of the hardware being tested; also of the test facilities and the personnel who operate these facilities.

When people are involved in any type of operation, the complexity of the task is increased many times due to their own inherent complexity, and their variability of behavior. Lack of complete understanding of personnel and problems, on the part of persons conducting the testing, is possibly one cause of human-initiated errors.

A further look at other possible causes of human errors in testing reveals that about 7 per cent of all tests resulted in failures due to errors originating during test preparations and actual hot firings. This percentage does not include errors made, then found and corrected, prior to firing. The number of errors made per test, then found-and-corrected prior to firing, if properly analyzed might lend additional insight into the causes of human-initiated malfunctions.

Other Causes — To examine other possible causes of human failures in testing one must look at the persons involved and the environment in which they work. These can not be regarded separately, since human beings are, indeed, influenced by the environment in which they work. Environmental factors to be studied might include the physical characteristics of the area in which the work is performed, backlog of work, personalities of those working with the person responsible for the error, personality of the supervisor, types and methods of communications used, and, factors outside the work environment that affect performance.

One might also investigate the overall performance of operations on a particular test facility or group of test facilities. It has been noted in reviewing the facility test results that if a steady work load with a backlog of work is provided, human errors may be reduced significantly.

Investigations of further aspects could broaden the study of human errors. For instance, frequencies of human error categories might be analyzed with relation to the incident of all kinds of test failures. Also human failures could be treated with reference to any or all of the following criteria: commission versus omission, result or type of shutdown, component versus engine, and carelessness versus ignorance. For, only through a comprehensive analysis of human-initiated malfunctions can we establish preventive procedures.

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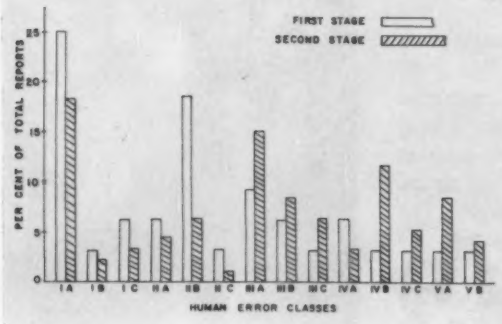
ANALYSIS OF HUMAN ERROR



First and Second Stage Titan Tests

Human Error Class	First Stage, %	Second Stage, %	Difference Between First And Second Stages, %	Standard Error of Difference	Critical Ratio
IA	25.00	18.46	6.54	8.23	0.795
IB	3.13	2.17	0.96	3.15	0.305
IC	6.25	3.26	2.99	4.04	0.740
IIA	6.25	4.35	1.90	4.41	0.431
IIB	18.75	6.52	12.23	6.07	2.015
IIC	3.13	1.09	2.04	2.58	0.791
IIIA	9.38	15.22	5.84	7.06	0.827
IIIB	6.25	8.69	2.44	5.59	0.436
IIIC	3.13	6.52	3.39	4.74	0.715
IVA	6.25	3.26	2.99	4.04	0.740
IVB	3.13	11.95	8.82	6.07	1.453
IVC	3.13	5.43	2.30	4.41	0.522
VA	3.13	8.69	5.56	5.32	1.045
VB	3.13	4.35	1.22	4.04	0.302

Based on a 1961 SAE Report

Weapon-System Planning and Control

- *Top military planners often ask "what if . . ." questions that throw management into a panic by rupturing time and cost ceilings.*
- *Six companies have worked with Air Force to develop a mathematical model that allows "homing" on best answers to these reprogramming questions.*
- *This scientific tool aids in making quick decisions without pulling top engineering talent off other important work. It is called WSPACS (Weapon-System Planning and Control System).*

This is How It Works . . .

by Lee A. Ohlinger, Director Computing and Data Processing Northrop Corp.

Most people think of the Air Force as "the customer." Not many consider Air Force "the management."

Classical theory defines the five principal management functions as planning, control, organizing, staffing and directing. Air Force exercises all of these within its own structure. It also exercises the first two, and strongest of these management functions, on 100 weapon-system program-complexes continuously. This certainly qualifies AF as "management."

Scientific Management — Air Force has been faced with the same problem that harasses industry: The need to recognize management's true place in the total scheme of things; and the need to convert the "art" of management to the "science" of management.

Too many people believe that better products and lower costs are simply the result of improved technology and manufacturing skills. Few realize the importance of management's part in achieving these goals. Few recognize that a bad management system can ruin the effects of the best skilled engineering and production workers.

The day of intuitive, "seat-of-the-pants" management is fast passing. The new tools of scientific management which we call Operations Research, aided and abetted by the newer mathematical tools and high speed computing and data processing equipment, are providing the opportunity for intelligent decision-making based upon scientific principles.

If scientific management can be applied to industry, it should be equally capable of being applied to the military in their capacity as managers of over 100 complete weapon systems programs.

Industry-AF Effort—The following is a summary of a joint effort by industry and the Air Force to pioneer new concepts in management.

The program complex of AFLC (Air Force Logistics Command) is a dynamic one. It is subject to change at any time. For example, Hq USAF at this minute could perform a simulation or gaming exercise on the program complex based upon a changed economic, military, or even political situation. The result of the gaming is to raise a number of "What if . . .?" questions. What if we cancel Project X? What if we give new funding to Project Y? Hq USAF, as top management, must have answers.

In the past, the request for such answers came through AMC to the affected contractors—very often on a Friday, with a Monday deadline. The result of such queries was the creation of a panic. It caused a drop in morale that reduced production. Some time was required before things were again on an even keel at the contractor's site.

For many years, Hq USAF, ARDC, and AMC were quite concerned with the magnitude of this programming and reprogramming problem. The pressure that finally sparked a new management method was generated out of sheer desperation by Major-General W. Austin Davis, then Director of Hq AMC Procurement and Production Staff Office and now Commander of ASC. He got tired of these periodic "crash" inquiries and "panic" operations and decided that "there must be a better way of doing things."

The Better Way—The Operations Research teams set up to develop this "better way" consisted of representatives from six of the major aircraft companies (Boeing, Convair, Douglas, Lockheed, North American, and Northrop) and of AMC and ARDC. The program was called the "WSPACS Study" (WSPACS is an acronym for Weapons Systems Programming And Control System). Its final configuration differs somewhat from the simple "panic averter" that it started out to be.

It was planned originally that WSPACS would provide simply the mathematical model by which the Air Force could answer these "crash" inquiries. But the development of the tool indicated even greater usefulness. WSPACS illustrates the benefits of good Operations Research applications in management principles.

In Operations Research the term "mathematical model" represents simply a mathematical statement of equalities and/or inequalities in the relationships of the parameters of the system described by the model. It does not imply that the model is single simple or complicated mathematical expression describing the system. It actually may consist of many mathematical statements. The term refers to the group of mathematical expressions describing the system, its behavior, and in some cases, the manipulation of the system to achieve specific objectives such as optimization based upon certain ground rules.

Problems and Objectives—Within the total program complex, it is not easy for the Air Force to break its decisions into small, independent packages, each relating only to a single program that is easy to understand and manage.

There is a very strong inter-dependence between many of the programs in the complex. For example, decisions made on the B-70 program are not independent of the Atlas program. They both not only draw from a common source of funds but their joint cost must not exceed fund ceilings. In addition, they at least partially replace each other in the weapons systems mix. More of one means fewer of the other. If one system is delayed, maintaining continuity of deterring capability means that the other must be accelerated correspondingly. Therefore, WSPACS must provide decision-making information not only to the individual weapon system but also upon the total program complex. It must provide the Air Force management with a broad planning device and provide Air Force and industry with a means of maintaining control and surveillance over the expenditure of their development and production moneys.

Man-Machine Management—WSPACS is a man-machine operation. The concept is that a body of data supplied by the various Air Force contractors will be stored in a computer. These data will represent the current Air Force program. It will consist of information that permits AF to estimate development and production costs, system-connected costs incurred as a result of introduction of weapons into the

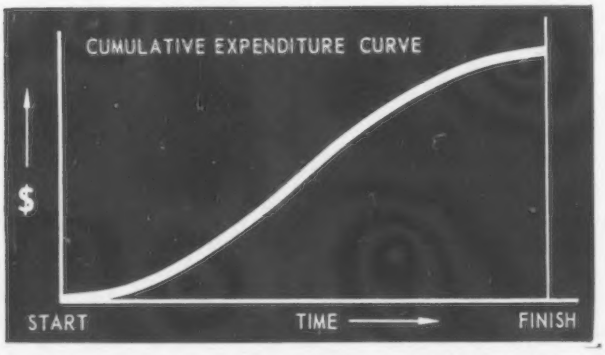


Fig. 1. Expenditure growth curve is important in the WSPACS concept. It contains basic data on costs and time.

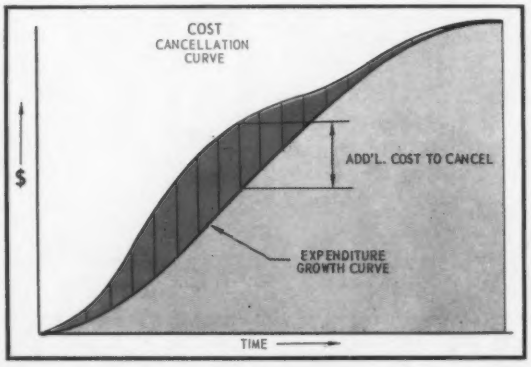


Fig. 2. Termination liability curve has its roots in the expenditure growth curve—shows cost of cancellation.

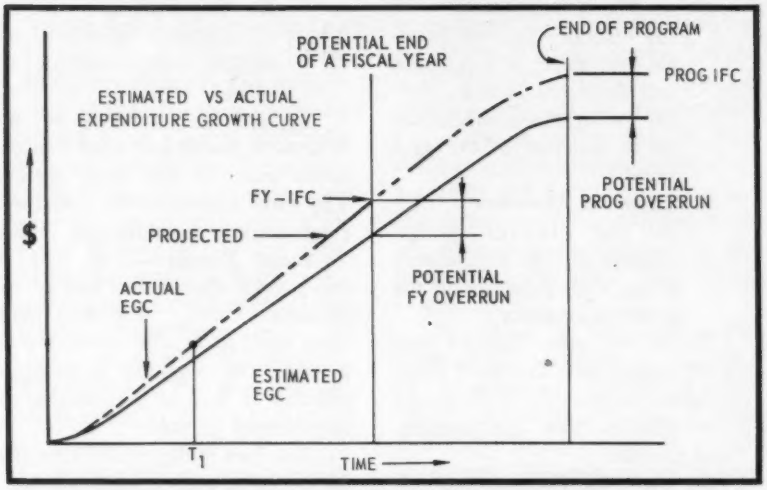


Fig. 3. Plotting actual expenditure against estimated expenditure and projecting to program completion gives IFC (Indicated Final Cost).

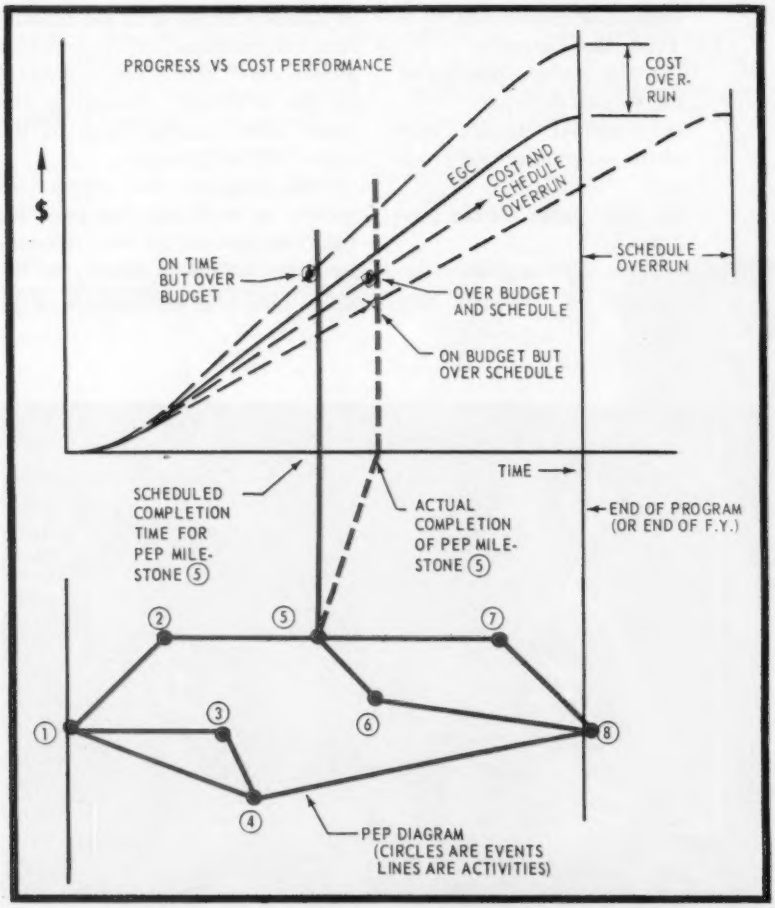


Fig. 4. PEP network can be worked into expenditure growth curve to correlate cost and performance. This is another tool to raise warning flags for management.

inventory, and various other types of pertinent information. When a reprogramming requirement arises, management will input an action into the computer which they consider most desirable in the face of the reprogramming requirement.

In a relatively short time, the computer will return to management the results of the proposed action. If the solution is not feasible because it calls for expenditures above the current or projected limitations, additional suggested solutions may be attempted until one is found which satisfies all financial and other constraints and, in addition, is compatible with management's decision with respect to a desirable Air Force structure.

Can't "Make" Decisions — WSPACS, like any other mechanized, "scientific" management system, will be a decision-aiding and not a decision-making tool. It will accept relatively large amounts of information and manipulate it according to the rules and constraints built into the model. But, the results will be given to management for evaluation and revision.

This really constitutes a "man-machine feedback" scheme that yields a "homing-in" technique for reaching decisions through the use of simulation. The manager again and again imposes new restrictions and constraints, lets the machine operate using its store of data and logical procedures, and views the outputs. The results of the computations are predictions of the conditions that would exist for the specific management plan under the current situational data.

Based upon these results, the manager can modify his plan, let the machine simulate the real world situation again, view the new results, and again modify the plan as necessary. Thus, he iterates toward or "homes in on" a solution that is most acceptable to him.

The WSPACS system is not meant to be a day-to-day adminis-

tration tool. It is a reprogramming tool suitable for fiscal and force structure planning in which any estimates provided are only carried to "order of magnitude" limits. More detailed planning is required before final decisions with respect to specific numbers of dollars to be allocated or committed can be made.

The WSPACS model will provide to the Air Force manager answers to the following areas of "What if . . .?" questions:

(1) The cost implications of stretch-out, acceleration, or cancellation of a program.

(2) The time implications of reducing or increasing the rate and/or amount of total program expenditures.

(3) The time and/or cost implications of a change in the number of end products or in the objectives of a program.

Such data from each of the contractors on each of their programs will provide the information for a simulation model that can be manipulated in accordance with strategic or tactical constraints in time and/or cost.

This gaming model is referred to as the "Total" or "Reprogramming" model since its function is to permit prediction of the effects of reprogramming upon controlling variable parameters.

There is one other phase of the WSPACS model that is developed from this input data. Since it is the component that raises a warning flag to direct attention to the need for action, it is referred to as the "Early Warning" model.

The Inputs—The minimum that the problem will accept as inputs, is information regarding the following variable parameters and their interrelation:

(1) **From the Contractor**
- (a) Time schedules for performance.
- (b) Estimated and actual costs as expenditure rates.
- (c) Cancellation costs.
- (d) Quantity of end products or scope of a research and development task.
- (e) Performance milestones to be reached in the program.

(2) **From the Customer**
- (a) The planned budget ceilings for the expenditure rates of all programs in the program complex.

There are other factors that should appear in a complete overall model, particularly if the model is to develop true optimization. These include:

(1) **From the Contractor**
- (a) Anticipated reliability factors.
- (b) Constraints based on contractor capabilities.

(2) **From the Customer**
- (a) The relative priority of the various programs.
- (b) Potential modifications of the program or end products.
- (c) The "value" of the program.
- (d) The defense posture (including the weapons systems mix) based on economic, political and strategic considerations.
- (e) Training effort required for the program.
- (f) Logistics support and facility construction required.

Sophisticated versions of the WSPACS model will take into account more of the latter factors. The initial version of the model will consider only the minimum inputs.

Input Details — The first of these input data is the rate of expenditure curve. Any well managed contractor will develop such a curve in planning a program whether it is a direct contractual requirement or not.

The data in the expenditure rate curve can be accumulated in a form that indicates the total estimated cost of the program as a function of time, as shown in Fig. 1. This curve is usually referred to as the cumulative expenditure or expenditure growth curve and is very important in the WSPACS concept as the basic curve relating most of the other WSPACS factors.

For example, this expenditure growth curve is also the basis for the "cancellation" or the "termination liability" curve, which is of the general form shown in Fig. 2. This

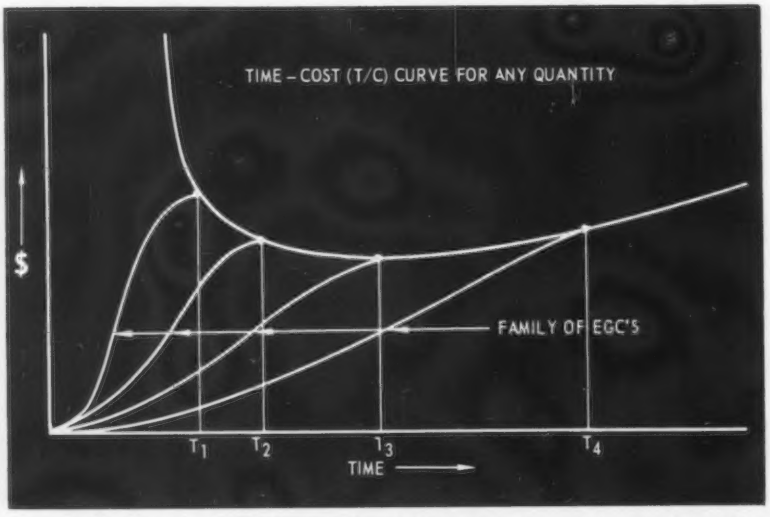


Fig. 5. Time-Cost, or T/C, curve shows that there is a minimum time within which a project can be completed regardless of cost.

curve can be estimated in advance as a function of the estimated expenditure curve and then maintained in relation to the actual expenditure growth curve.

By continuously plotting the actual expenditure growth curve against the estimated, and projecting the actual growth curve to an Indicated Final Cost or IFC, the contractors and the Air Force have an indication of the following: Cost performance in comparison with the planned performance at any time. A warning flag that indicates a potential out-of-control condition that will exist at some future time. The probable degree of this out-of-control condition. The need for immediate action to obviate the threatened condition. (See Fig. 3.)

The expenditure growth curve can also be used to correlate performance and cost. Fig. 4 indicates such a relationship using an oversimplified PEP network. It shows how this provides another tool for management by raising warning flags that a potential out-of-control condition exists or is threatened.

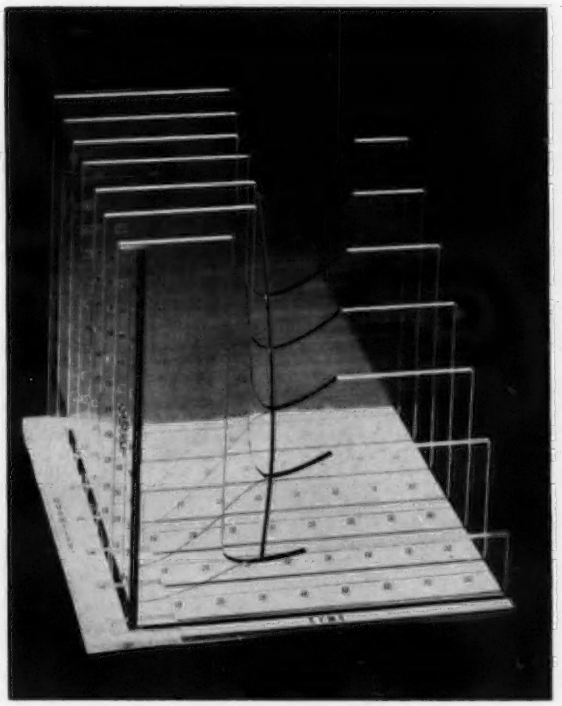
There is another relationship between time and cost in the performance of a contract that is not normally generated by contractors in estimating and planning work. It is necessary in providing data for the WSPACS model, however. This is the Time-Cost or T/C relationship of a program. It has the general shape shown in Fig. 5. This curve compares the cost of pursuing a certain task (whether it be a research program of a specified number of end product items) to the time within which that same task is completed.

In a sense, the T/C curve is the locus of the end point of a family of Expenditure Growth Curves (EGC) as indicated in Fig. 5. The T/C curve is not a **static** curve but is a very **dynamic** curve which changes as a function of time after go-ahead of a contract. Once a particular EGC and, therefore, a point on the T/C curve has been selected and some work performed, the original T/C curve ceases to be valid and a new curve must be generated for reprogramming.

The T/C curve logically has a vertical asymptote which represents the minimum time within which a program can be completed regardless of cost. Experience in turn indicates that the T/C curve is usually relatively flat near the optimum or minimum cost but does rise again as the time is increased beyond that required for minimum cost. There would appear to be some relationship between the rise of this leg of the curve and the fixed costs involved in a particular program.

Although the T/C curve has been discussed as though it were a single curve developed for an entire program, there really are separate T/C curves for each of the various functions and operations that go to make up the performance of a program, i.e., engineering, tooling, production, etc. The T/C relationship also exists for the various components of a weapons system or vehicle such as the airframe, propulsion unit, etc. In other words, there is an actual matrix of T/C curves for any total system. For

Fig. 7. Time-Quantity-Cost relationship produces a three-dimensional model. Reprogramming affects it like a shrinking universe ending as a point in space. ▶



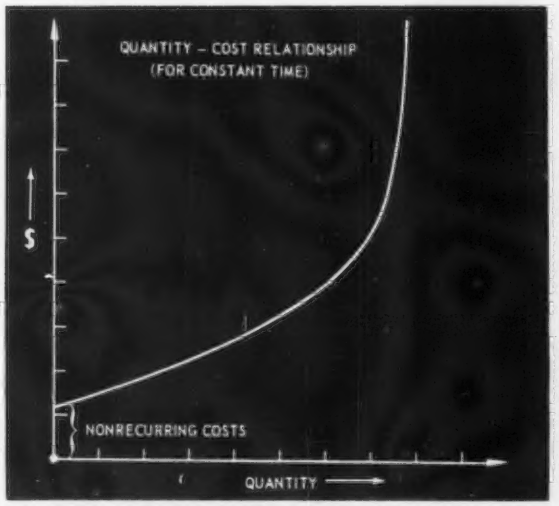


Fig. 6. Relationship exists between quantity of product produced and cost. It is called the Q/C curve.

simplicity, we shall refer to a T/C curve for the total system, keeping in mind that the total system is comprised of many elements.

There is a similar relationship that exists between the quantity of product produced and the cost for any specified time of performance, and this curve has the general shape shown in Fig. 6. Although there may be certain discrete discontinuities that are a function of contractor capabilities in tooling, equipment, and man-power. Reprogramming changes in the Q/C relationship for any specified time will depend upon the number of products produced up to that time and upon a number of factors such as the status of the tooling, plant capabilities, manpower, etc.

Obviously, the time - quantity-cost (T/Q/C) relationship produces a three-dimensional surface. Reprogramming affects it like a shrinking universe that ultimately winds up in a single point in space. (See Fig. 7.)

The Output — On individual programs, the PEPCO correlation and the IFC projection yield outputs that give warning of existing or potential out-of-control conditions requiring action by contractor management or reprogramming by the Air Force. The only time that the total program complex is affected by the Early Warning segment of the model is when the contractor is unable to regain control.

The principal output of the Total or Reprogramming model is a comparison between the costs of the total program complex and the budget ceilings prescribed by higher authorities. The total expenditure rate generated by all of the Air Force programs must lie below the expenditure rate ceiling as indicated in Fig. 8. If, at any time, this ceiling is ruptured by the acceleration deceleration, or cancellation of a single program or group of programs (as indicated by the dotted conditions in Fig. 8, then action must be taken by the Air Force in order to bring the monthly rate of expenditure back under control.

This action is the simulation of a new program complex and the determination by the WSPACS model of whether the proposed reprogramming (such as acceleration, deceleration, cancellation, or change in quantity) causes a repair in the rupture.

By repeated simulated reprogramming or gaming, it is possible to arrive at a new program complex. It is even possible by this trial-and-error method to arrive at an optimization that will accomplish the Air Force's objectives at minimum cost. It is also possible to develop the model in such a way that it will perform automatically the "homing-in" processes of optimization within the constraints defined by management.

Similarly, this total reprogramming model of WSPACS can be used to determine whether a newly proposed program, not yet in the Air Force program inventory, will cause a rupture in the budget and, if so, how it can be fitted into the budget by reprogramming existing programs.

Final Model — The completed model accepted by the Air Force and industry will be programmed for large scale electronic data processing equipment. It will be tested by the various Air Force contractors in an attempt to fit it to their past, present, and future operations and test the validity of the WSPACS model concept. This means the application of their own coefficients and factors that will make the model applicable to their particular programs and company operations.

When the model has thus been proven or modified an investigation will be made into the current methods of data acquisition and presentation for all AFLC contractors. This is necessary because some of the data needed for WSPACS is currently in other Air Force reports while some of the data has never been reported. Obviously, one of the objectives of WSPACS will be to attempt to reduce the total amount of reporting to the Air Force rather than increase it.

The final step in WSPACS will be the incorporation of visual display. This is as near the ultimate in the man-machine relationship as we care to go. There must be reserved to man those decisions requiring human judgment.

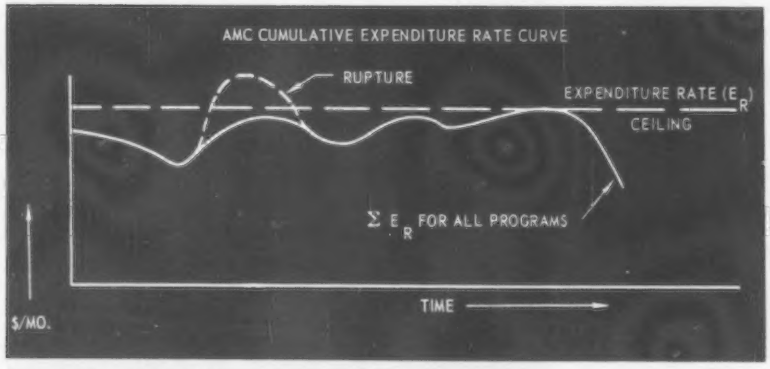


Fig. 8. Rupture of the expenditure-rate ceiling can result from acceleration or cancellation of programs. This requires an entire reprogramming.

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How UTC Invaded A Major Market

- *Two men urged United Aircraft to build a solid-propellant capability.*
- *Four others built the United Technology Div. into a "top contender" for big booster contracts.*
- *Here is a penetrating analysis of why a large corporation allowed these men to commit $30 million of company funds for plant facilities without a contract in hand.*

by Philip Geddes

Mix half a dozen farsighted men with a belief in the future of solid rockets. Then add a solid Company with a reputation for being "Real Yankee entrepreneurs" and a potentially important company is born, despite the competition. In 1961, it is very easy to predict the extensive use of large solid rockets in the future. Several capable companies say with assurance that they can make a large multi-million pound booster and few people disbelieve them. The doubts associated with solid rocket ICBM's have vanished with success of Polaris and early Minuteman. There may be problems but none of them is far beyond present state of the art development. In the period 1957/58 there was not this same assurance of success.

The perplexing question of the wisdom in founding a solid rocket corporation at a time, when on the surface at least, all R&D and production requirements could be met by existing companies, can only be answered by tracing the beginnings of United Technology Corporation (UTC).

Origins — UTC's parent, the United Aircraft Corp., has been a major company in the aircraft propulsion field for many years. Of 159 large commercial jets on order in 1960, 122 of them were powered by Pratt & Whitney engines, from the largest company in United Aircraft Corp. Pratt and Whitney in 1958 were committed to large volume jet engine production and while they believed in a continuing demand for jet engines for many years, they also believed that the long range market was not good for growth. If the jet engine market peak was near, where should the company concentrate its effort for the future? For a propulsion company the answer was simple, in rockets. Hence the founding of the rocket engine division in West Palm Beach, Fla. in 1956. The dominant place the company gained in the past as an engine manufacturer was based on its ability to leapfrog the competition in producing workable advanced designs. P&W efforts in liquid rocketry are aimed at advanced hydrogen engines, not low-energy fuel versions.

Gen. Putt, President of UTC

First Steps — The unembroidered truth about the solid rocket field is that it is unique in propulsion. The skills and facilities of jet and liquid rocket producers are incompatible with the research and development of solid propellants and their chemistry. The ability to build cases is much less than half the problem. A solid rocket must be tailored to the ballistics of its use. Credit for the urge to move United Aircraft into the solid rocket field goes to Vice President of Engineering, Wright Parkins, since retired, and Vice President and Chief

UTC executive quartet in conference (from left) Altman, Adelman, Lawrence, and Putt.

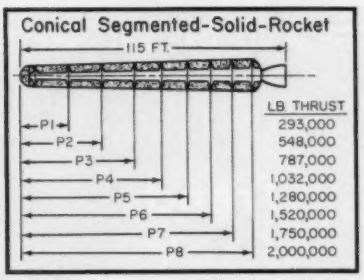
Scientist Perry Pratt. Future-market studies for a proven product line are sure indicators of the path to follow in expansion, but studies which can be performed on beliefs in the future of an unknown quantity add up to very little. Contact with independent company and Air Force researchers convinced the two UAC V.P.'s of the future role of the solid rocket in ICBM's and space. And what of the competition? It existed in strength — Polaris was being firmed and Minuteman was coming. The conclusion? We cannot break into existing markets since we have neither the facilities, the scientific skill nor the proven capability required to gain contracts. If we wish to move into the field, we must found a research corporation and acquire a nucleus of people with the technical skills, who will evolve or monitor the evolution of a superior propulsion system to leapfrog the existing state of the art.

To this end talks on the founding of United Research Corporation were held in Hartford, Conn. in the first half of 1958. In October, 1958 a corporation was founded under the leadership of a recently retired Air Force officer with a distinguished career in research. URC was born with one man, Lt. General Donald L. Putt, and a secretary.

A remarkable transformation in the philosophy of the newly-born company took place with startling rapidity due completely to the confidence and ability of the people drawn in to direct the company. URC of Menlo Park was supposed to be a sponsored contract research organization which would encourage and survey solid-propellant research with institutes, colleges and individual experts across the country. From this study would eventually come a sufficiently advanced propulsion system or propellant which would justify founding a production company. A research contract was signed in December 1958 with the Stanford Research Institute to start work . . . some new facilities would be needed by Stanford Research to do this work.

The Men—Barnet R. Adelman, Executive Vice President and Director of Operations; Dr. David Altman, Vice President and Director of Research; and Herbert R. Lawrence, Vice President and Director of Engineering; joined United Research in the first quarter of 1959. With General Putt, they came to an abrupt conclusion which was the death knell of United Research: there was insufficient forward-looking research in the field, and that by the time something superior to the state of the art came out of the laboratory, in perhaps four or five years, the market would be gone for their embryo corporation. In short, if they were going to get into solid rockets, all the major systems would already be committed by the time they could move. In early 1959, a proposal was made to the parent corporation to found a development and production corporation, United Technology.

Adelman on top of big segmented case.



Thrust buildup of segments.

The Decision—The proposal offered by General Putt and his group to United Aircraft was direct. If we go on with contract research we will miss the market. In a short space of time we can develop our own R&D and our own facilities. Instead of the existing two- or three-million-dollar/year operation we will need more money, much more. The general says, "It was a very short conversation." By March 1959, United Technology was looking for land.

In essence the informal proposals made to support the proposed founding of United Technology give direct insight into their goals, their possible success and an estimate of the future of the solid rocket market.

The Goal—The best available people would be drawn into a group with the facilities and tools required to do the job and given the support necessary with company funds. The right group would be able to compete technologically with the field and satisfy the United Aircraft Corp. urge to leapfrog the competition. From the founding precept that the company would be able to do a better job with fewer people than customary, would according to executive vice president Adelman, "engender a spirit of fixed-price contracting, with a free-enterprise approach to solid-rocket making, risk and profit being the base of free enterprise. There is a tendency to equate profit-consciousness with cost-consciousness and the two are not always compatible."

The Market—What of the market seen through 1959 eyes. UTC long-range market-planning showed that the mid-sixties would offer a firm market for big space-boosters much higher than the $200 million a year for 1959. A strictly proportional share of the mid-sixties market alone would justify the investment in entering the field.

According to Barnet Adelman, there are presently five companies in the field, two of which do 95 per cent of the business. UTC guesses are that there will soon be three, including UTC. We are now moving into the big space-booster market, there are succeeding generations of solid-rocket boosters for ICBM's past the early-planning stage, there has been a lot of talk of a "small missile."

UTC say unhesitantly that the specific impulse of their propellant is comparable to the best although its physical properties are considerably better than any others available for large boosters. The conical segmented approach to large boosters is held superior to cylindrical segments but the technology for both from a design starting point is the same.

Today—Every company makes claims for its prowess in its own field. Where does UTC stand right now? In terms of the contenders for the solid rocket business, they see themselves somewhere in the group with Aerojet-General and Thiokol. Aerojet is in a good position because it carried off the first AF contract for a large solid booster. Thiokol, while strong, has a near saturated plant capacity. UTC's leap-frog into a competitive position with the major propulsion companies resulted from two years of active project efforts on large solid-rockets. The strong talking point for UTC's present strength at Sunnyvale is that they are committed to a program based on an actual large segmented booster of 250,000 pounds thrust for 60 sec. in flight-weight hardware scheduled to fire in Summer 1961. Emphasis is placed on flight-weight since no other company has test fired such an engine. According to Dr. Altman, this puts UTC a long way ahead of the field since other companies have fired engines of high thrust but for shorter inadequate time periods in boilerplate cases.

As for finance, expectations are that the end of 1963 will see United Technology breaking even. "Although it will be a considerable time before the investment in the facilities (estimated replacement value, $30 million) is returned." Contracts in the house except for the 250,000-lb booster valued at $1.8 million are still small and are of a research nature.

If confidence breeds success, there is no doubt of UTC's future.

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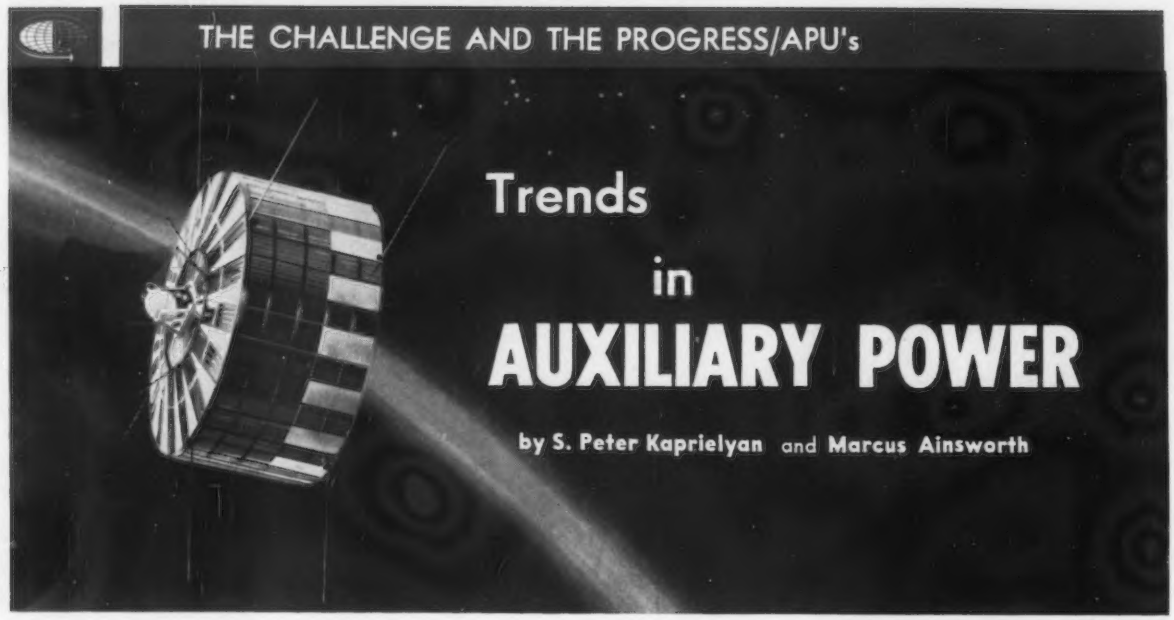


Trends in AUXILIARY POWER

by S. Peter Kaprielyan and Marcus Ainsworth

Arrival of the triple-payload transit IV-A in space, on June 29 had a dual significance: it proved the feasibility of multiple-payload launching; it also marked the entry of nuclear auxiliary-power in space exploration.

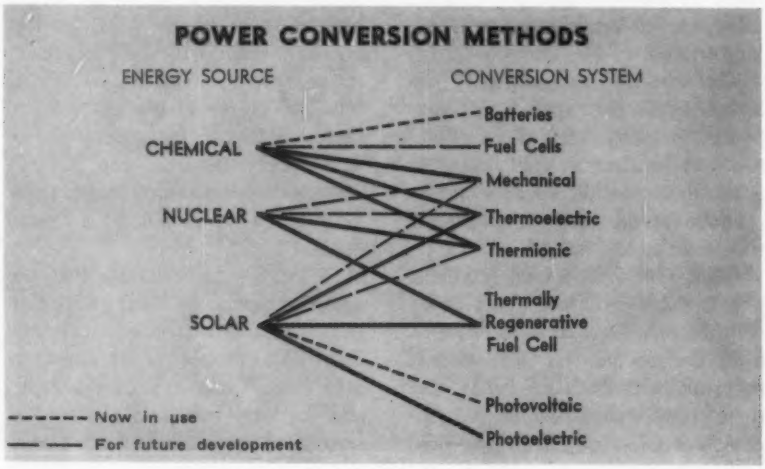
From the first installation of landing and navigation lights, in early aircraft, airborne-power requirements have been mounting. The same trend is evident in space-vehicle power needs.

Aircraft Power Needs—The list of tasks assigned to auxiliary power systems is expanding rapidly both for commercial and military aircraft. Inflight power needs for commercial aircraft are for: cabin pressurization, air conditioning, deicing, communications, navigation, and for driving the host of electric motors in the fuel, hydraulic and control systems. A new category of tasks is now in the offing. These are aimed at making commercial vehicles completely self-supporting even when on the ground. Aircraft-mounted auxiliary turbine units are now being use for: ground checkout of electrical systems, starting, engine warmup, ground air-conditioning, operating ramps, etc. Accompanying pie-chart shows the electrical load requirements for military and commercial aircraft.

Military aircraft major loads are mostly for electronic subsystems. These include defensive subsystems, bombing, navigation and missile guidance subsystems, and the mission and traffic-control subsystems.

Space Vehicle Power—Need for electrical power is especially acute both for manned and unmanned vehicles. For, unless compact and reliable power generation or conversion systems are developed concurrently with the big boosters, the Saturns and the Novas will serve only limited purposes.

Foreseeable tasks of space power systems include: vehicle attitude control, propulsion system actuation, operation of communication systems and of tracking beacons, orientation of telescopes, oper-



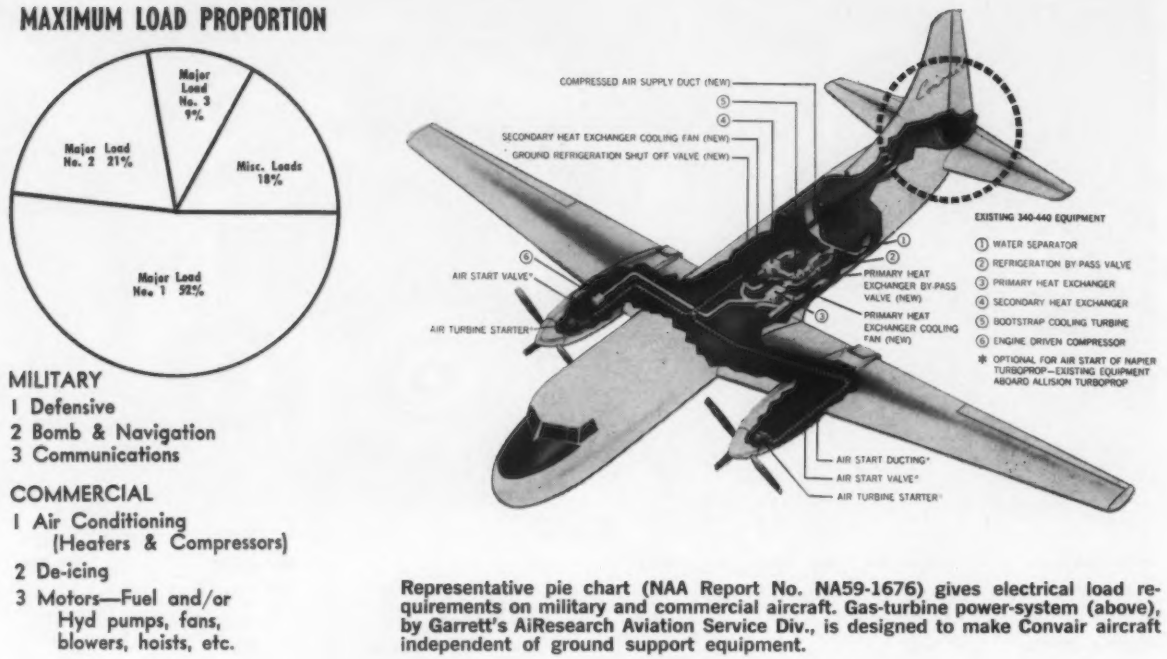
AEROSPACE POWER UNITS

Data Compiled by Aerospace Management Special Survey

MAKE AND MODEL	Stage of Progress	OVERALL DIMENSIONS: Length (In.)	Width (In.)	Height or O.D. (In.)	Dry Weight (Lb.)	PERFORMANCE: Horsepower	Kilowatts	Fuel	COMBUSTION CHAMBER: Type	Operating Temperature Range (Deg. F.)	Type of Igniter	Intended Environment	Major Materials of Construction	OPERATING CYCLE: Between Refueling (Hr.)	Between Overhaul (Hr.)	APPLICATION
Atomic Energy Commission																
Aerojet-General; Atomics International SNAP-8	Dev	45.0[1]	22.0[1]	30.0[1]	1050[2]		30/60	Uran		1200		Sp		10000		Sp. Pow.
AGAL-0010	Pro	20.0	16.3	16.0	90	2-26		J-H		1325		AS	St, Mag			Hyd. Ele.
AGAL-0020	Pro	40.0	24.0	18.0	180	15		PN		2300		At	St, Alu			Hyd. Ele. Pn.
AE-52-3000	Pro	10.0	9.4	5.5	40		½	SP		2390		At	St, Alu	85[3]		Gas Gen.
AGAS-0011	Pro	23.0	6.9	7.5	14	0-3		SP		1800		AS	St, Alu	120[3]		Gas Gen.
Atomics International SNAP-2	Dev				250		3	Uran		1200		Sp	Be, SS	10000		Sp. Pow.
SNAP-10-A	Dev				620		½	Uran		1000		Sp	Be, SS	10000		Sp. Pow.
The Martin Co. SNAP-3	Dev	5.5		4.8	4		3½[8]	Pol		175 to 720				1[7]		
	Dev	20.0		18.0	1680		5[8]	Str						2[7]		Gen.
American Rocket		1.0		1.5	.055			SP		900 to 1000	HP			50-100[3]		Gas Gen.
Clark Bros. 305-S		573.0	132.0	196.0	125000	9000	6350	G-O		1350		At	St		100000	
CSN-1		81.0	32.0	32.0	6500	600	450			1200		At	St		50000	
Douglas Aircraft PN-9019677	Pro	34.5	15.6	14.0	113							AS	Alu, St	7[4]		Hyd. Pump
General Electric AM-10	Pro	9.0	11.0	16.0	46	40		H Per	Cy	1350	N	AS	SS, Alu	.5	150	
AM-31	Pro	10.5		12.0	40	10-40		H Per	Cy	1350	N	Sp	SS, Alu	.2		
AM-32	Pro	10.5		12.0	30	25		H Per	Cy	1350	N	Sp	SS, Alu	.2		
Grand Central Rocket Fang	Pro	4.7		1.5	.822	39.5[5]		SP	Cy	−35 to 160	Spk	AS	St			RM
Sword	Pro	55.8		6.5	98.86	4090[5]		SP	Cy	−10 to 130	Spk	AS	St			RM
Saber	Pro	109.0		6.7	220.6	9900[5]		SP	Cy	30 to 130	Spk	AS	St			RM
Viper	Pro	106.9		6.5	189.4	5400[5]		SP	Cy	30 to 130	Spk	AS	St			RM
Javelin	Pro	100.3		9.0	353.4	24400[5]		SP	Cy	30 to 130	Spk	AS	St			RM
Kidde Aero-Space WK-1131	Pro	36.0	18.0	24.0	265[6]	50		EO		−65 to 650				4		
WK-2000	Pro	29.0	25.0	16.0	290[6]	70		Hyrz		−65 to 450				4		
WK-1028	Dev	21.0	10.0	10.0	45	8		H Per		−65 to 160				10[4]		
WK-2146	Dev	11.0	6.0	6.0	10	6		SP		−65 to 160				¾[4]		
WK-1160	Dev	36.0	18.0	16.0	115[6]	55		EO		−65 to 160				⅓		
WK-325	Dev	30.0	10.0	12.0	62[6]	20		EO		−65 to 160				8[4]		
WK-142	Dev	20.5	14.0	17.5	129[6]	25		Hyrz		−65 to 160				2		
Rocketdyne MK. 2-Mod. 1		12.0		5.0				SP	Cy		Elec	AS	St			Gas Gen.
MK. 3-Mod. 1		12.0		5.0				SP	Cy		Elec	AS	St			Gas Gen.
Liquid Engine Turbine Starter		8.0		6.0		3140-5950		SP	Cy	−30 to 165	Elec	At	St			
Cartridge for A3J Stores Ejector		15.0		4.0				SP	Cy	−65 to 160	Elec	At	St			
Jet Engine Starter Cartridge		8.6		6.5	11.5	430		SP	Cy	−65 to 170	Elec	At	St			
Sundstrand-Denver 871-A	Dev	30.0	15.0	20.0	140	52		Hyrz		2000	Hyp	Sp	St	4½	100	
Solar APU	Dev	288.0		528.0	1009		15			1750	N	Sp	St	1[7]		
1290	Dev.	20.0	10.0	10.0	40	8		H-O		300	Cat	Sp	St	300	1000	
875	Dev.	40.0	20.0	20.0	185			H-O		300	Cat	Sp	St	125[4]	1000	
Thompson, Ramo, Wooldridge 9978	Dev	10.0		7.0	20	140		H Per						½		Pu. Dr.
TU-147000	Pro	8.0		3.0	5.5		.2	SP						1½[4]		
TU-145000	Dev	24.0	24.0	12.0	170		16	Hyrz						½		
TU-112700	Dev	27.3	15.3	24.7	260		37	Hyrz						2		
TU-132000-B	Pro	10.0		7.0	17		1.3	SP						1½[4]		
TU-132000-A	Pro	11.0		7.0	9	7.3		SP						1½[4]		
Vickers EA-1065-033	Dev	12.0	2.5	13.5	20	5.4										Hyd. Pump
EA-1085-025-A	Dev	12.0	7.0	11.0	20	10.0		SP								Gas Gen.
EA-1085-025-B	Dev	12.0	6.0	9.0	15	5.0		SP								Gas Gen.
EA-1085-025-C	Dev	11.0	5.0	7.0	10	2.0		SP								Gas Gen.
EA-1065-065-6	Pro	11.0	6.5	5.0	12	.85		Bat								Hyd. Sys.
EA-1065-065-4	Pro	12.0	6.0	5.5	17	3.3		Bat								Hyd. Sys.
EA-1065-065-2	Pro	12.0	6.0	5.5	20	4.5		Bat								Hyd. Sys.
EA-50092-8	Pro	30.0	12.0	14.0	56	3.5		LP								Hyd. Fu. Sys.
EA-1080-022	Dev	6.0		10.0	20			LO								Hyd. Ele.
Winder Aircraft		15.0	8.0	8.0								Sp				
		24.0	15.0	15.0				G				At	Alu	1		

ABBREVIATIONS

[1]—Does not include extended radiator.
[2]—Does not include reactor.
[3]—Seconds.
[4]—Minutes.
[5]—Pounds of thrust.
[6]—Less fuel tank.
[7]—Year.
[8]—Watts.
Alu—Aluminum.
AS—Atmosphere and space.
At—Atmosphere.
Bat—Battery.
Be—Beryllium.
Cat—Catalytic.
Cy—Cylindrical.
Dev—Development.
Elec—Electric.
EO—Ethylene oxide.
G—Gasoline.
Gas Gen.—Gas Generator.
Gen—Generator.
G-O—Gasoline or oil.
H-O—Hydrogen and oxygen.
HP—Hot wire or pyrotechnic device.
H Per—Hydrogen peroxide.
Hyd. Ele.—Hydraulic and electric power.
Hyd. Ele. Pn.—Hydraulic, electric or pneumatic power.
Hyd. Fu. Sys.—Hydraulic and fuel system.
Hyd. Pump—Hydraulic pump.
Hyd. Sys.—Hydraulic system.
Hyp—Hypergolic.
Hyrz—Hydrazine.
J-H—Jet fuel and liquid oxygen or hydrazine.
LO—Liquid oxygen.
LP—Liquid propellant.
Mag—Magnesium.
N—No or none.
PN—Normal propyl nitrate.
Pol—Polonium 210.
Pro—Production.
Pu. Dr.—Pump drive.
RM—Rocket motor.
Sp—Space.
Sp. Pow.—Space power system.
SP—Solid propellant.
Spk—Spark.
SS—Stainless steel.
St—Steel.
Str—Strontium 90.
Uran—Uranium 235.


MAXIMUM LOAD PROPORTION
Major Load No. 3 9%
Misc. Loads 18%
Major Load No. 2 21%
Major Load No. 1 52%
MILITARY
1 Defensive
2 Bomb & Navigation
3 Communications
COMMERCIAL
1 Air Conditioning (Heaters & Compressors)
2 De-icing
3 Motors—Fuel and/or Hyd pumps, fans, blowers, hoists, etc.
COMPRESSED AIR SUPPLY DUCT (NEW)
SECONDARY HEAT EXCHANGER COOLING FAN (NEW)
GROUND REFRIGERATION SHUT OFF VALVE (NEW)
AIR START VALVE*
AIR TURBINE STARTER*
PRIMARY HEAT EXCHANGER BY-PASS VALVE (NEW)
PRIMARY HEAT EXCHANGER COOLING FAN (NEW)
AIR START DUCTING*
AIR START VALVE*
AIR TURBINE STARTER*
EXISTING 340-440 EQUIPMENT
1 WATER SEPARATOR
2 REFRIGERATION BY-PASS VALVE
3 PRIMARY HEAT EXCHANGER
4 SECONDARY HEAT EXCHANGER
5 BOOTSTRAP COOLING TURBINE
6 ENGINE DRIVEN COMPRESSOR
* OPTIONAL FOR AIR START OF NAPIER TURBOPROP—EXISTING EQUIPMENT ABOARD ALLISON TURBOPROP

Representative pie chart (NAA Report No. NA59-1676) gives electrical load requirements on military and commercial aircraft. Gas-turbine power-system (above), by Garrett's AiResearch Aviation Service Div., is designed to make Convair aircraft independent of ground support equipment.

ation of vehicles on the Moon and planets, control of internal environment, and the fulfillment of numerous mechanical tasks by robot systems.

Thus far batteries have been the prime source for satellite and missile power. However, when the weight penalty of the Mercury capsule's battery system is considered, the need for more efficient power sources becomes obvious. Some 144 lb of silver-zinc batteries are used in the manned capsule to yield an average power of 70 watts, including an emergency reserve.

NASA estimates that nearly all the space vehicles scheduled through 1964 will need average power levels of about 250 watts. Many of the scientific satellites launched by Scout or Delta vehicles will require less than 10 watts. Average power drain of Pioneer and Tiros (A&M June 1961, p. 57) satellites is 20 to 30 watts. Over 100 watts will be needed for Ranger "Scientific Bus" (A&M Sept. 1960, p. 21) which will carry instrumentation to Moon, Mars and Venus.

For manned lunar circumnavigation using the Saturn booster, NASA estimates a need for an average power level of 1.2 kw for 14 days, or a total of 400 kw-hr. This may well extend to 1 to 3 kw with peak power of 4 to 6 kw for a manned orbiting laboratory.

Many variations of power-conversion methods are now under study, to meet future requirements for electrical power in space vehicles. Presently the most promising energy sources considered for power generation in space are: chemical, nuclear and solar.

Problem Areas—NASA is interested in developing improved solar and electrochemical power systems which may overcome the drawbacks of current solar-cell power supplies:

- Degradation of solar-cell power-output caused by radiation damage from protons and electrons in the Van Allen belts.
- Unreliability of storage batteries in a vacuum, particularly with multiple re-cycling at high ambient temperature.
- High cost of producing and installing solar cells, which near $500,000 per electric kilowatt.

Organizations engaged in solar-cell research include: Jet Propulsion Laboratory, Radio Corp. of America, Boeing, and Electro-Optical Systems.

When the feasibility of reliable, long-life, self-sustaining power systems becomes established, these "auxiliary" systems would be used for propulsion also.

Mercury Boilers—Presently in development, the Sunflower and SNAP (Systems for Nuclear Auxiliary Power) series hold this potential. Both the Sunflower I and the SNAP-8 use the turbogenerator system. Heat supplied by the Sun in Sunflower I or by fission in nuclear

ENERGY CONVERSION TECHNIQUES*

FORM OF ENERGY SOURCE	ULTIMATE STORAGE POTENTIAL BTU/LB	FORM OF ENERGY DELIVERED BY SYSTEM				
		Thrust	Electric Power	Mechanical	Chemical	Thermal
BASIC FORMS						
Solar electro-magnetic	Nil	Solar Sail	Photovoltaic cell	—	Fuel cell regeneration	Solar collector
Electrochemical cells	200	—	Batteries Fuel cells	—	—	—
Expendable fuels	7×10^3	Combustion rocket motor	Fuel cells	Combustion-driven engine turbine, etc.		Combustion source
Nuclear fission and fusion	5×10^{10}	Direct expulsion of products	Direct conversion	—	—	Reactor
Radioisotopes	3×10^5	—	Thermoelectric couple Atomic battery Thermionic diode	—	Fuel cell regeneration	Isotope heat chamber
INTERMEDIATE FORMS						
Chemical	7×10^2	—	Fuel cell	—	—	Combustion
Thermal	10^3	Light gas rockets	Thermoelectric couple Thermionic diode	Engine or turbine	Fuel cell regeneration	—
Mechanical	20	Adiabatic expansion in nozzle	Rotary generator	—	—	—
Electric	200	Plasma rocket Ion propulsion	Rectifier, alternator, transformer	Motor	Electrolysis	Arc discharge

* Compiled by Battelle Memorial Institute.

reactor of NSAP-8 (A&M, May 61, p. 23) is used to boil mercury. The resulting mercury vapor drives a turbine which in turn drives the pumps and the electric generators in system. Mercury vapor then passes through a space radiator where it is condensed to re-start the cycle. The Tapco Group of Thompson Ramo-Wooldridge has the Sunflower contract, under the direction of NASA's Lewis Research Center.

Sunflower I will generate 3 kw. In this system Sun's rays are reflected and focused by a 32-ft collector on a boiler unit. Turbogenerator of Sunflower I is a modified version of the one being developed by Atomic Energy Commission for SNAP-2. Sunflower I will supply auxiliary power for Centaur and Saturn vehicles.

The SNAP-8 system will develop 30 kw; however, two turbogenerators can be operated with a single reactor to develop 60 kw. NASA Assistant Director for Propulsion, Elliot Mitchell, estimates that such power levels would give detailed - communications capabilities over interplanetary distances and provide power for early electrical propulsion applications.

High - Power Team Effort— Looking several years into the future, the Air Force Wright Air Development Division had earlier awarded a $1.5-million feasibility-study contract for SPUR a 300 kw nuclear turboelectric power generator to Garrett's AiResearch Manufacturing Div., Arizona. SPUR team effort includes: AiResearch Mfg. Div., systems manager; Aerojet-General Nucleonics, prime subcontractor for development of reactor; Westinghouse Electric Corp., for development of 300 kw alternator; and Battelle, for material tests. AiResearch Mfg. Div., Los Angeles would develop the heat-transfer components: boiler, condenser and radiator.

With the recent successful conclusion of this feasibility study, Garrett feels that a system of this type can be built for prototype testing by early 1966.

For applications of electrical propulsion to vehicles larger than Centaur, requirements include: more power, extreme lightness, and capability to operate for over a year without maintenance. NASA estimates the application of electrical propulsion of Saturn vehicle will require about 1000 kw.

Major objective of NASA's advance technology program is to support broad research on power generation techniques for future needs. To this end, the following sums have been earmarked for fiscal '62: $6.8 million for electric propulsion studies, and $5.5 million for research in space power technology.

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INTELLIGENCE REPORT

Russia's Helicopters

by James D. McGuire, Office of the Assistant Chief of Staff for Intelligence, Department of the Army.

In helicopter development, the Soviets claim a number of scientific firsts. According to Soviet literature, the first theoretical design of a helicopter was created by a Russian, Mikhail V. Lomonosov, in the 18th century. Using a simple clock spring for an engine driving two coaxial counterrotating rotors, Lomonosov built a small flying machine to lift weather instruments.

First or not, the recent air show in Moscow showed that helicopters have received considerable attention in Russia. The Vostok-toting Hook, shown above, and its crane counterpart have a greater size and lift capability than any in the world.

Chief Contributors — Russian helicopters resulted largely from the efforts of three designers—Nikolai I. Kamov, Mikhail I. Mil, and Aleksandr S. Yakovlev. Kamov began his rotary-wing efforts about 1930 when he joined the Central Aero - Hydro - dynamic Institute (TsAGI) in Moscow where experimental work on autogyros was underway. In 1948, he developed the KA-10 helicopter. This helicopter and all of Kamov's later designs are characterized by counter-rotating coaxial three-bladed rotors and twin rudder assembly.

Mil who also worked on various TsAGI autogyros began work on the Hare (MI-1) about 1949. All of his designs have the conventional single main rotor and small antitorque tail rotor. Yakovlev, a well-known designer of fighter aircraft, began his work on helicopters in 1953 by supervising the design of a large helicopter with twin rotors in tandem. This helicopter was designated YAK-24, and made an appearance at Tushino in 1955.

Since the turn of the century theoretical studies in helicopters have been underway in the USSR, but not much practical progress was made prior to W.W. II because of the poor weight-to-power ratio of engines then in existence. Prior to W.W. I, two names were foremost. These were Igor I. Sikorsky and Boris N. Yuriev.

During the years between the world wars, rotary-wing production was limited to small autogyros used for communications work. A prototype of the Omega two-seat helicopter was test flown in 1941, but development was halted until after W.W. II. In 1949, high priority and intense effort were devoted to the development of the helicopter. This resulted in the development and production of the current Soviet helicopters which are classified by their military roles: observation, utility, and transport.

Observation Helicopters — The Hat is an ultralight, single-seat helicopter designed primarily as a prototype test vehicle from which later similar types were developed. It is equipped with two coaxial, counter-rotating, three-bladed rotors which eliminate the need for an antitorque tail-rotor. Directional stability is provided by two vertical tail fins. The helicopter is turned by differentiating the pitch of the rotors through foot pedals. Rotor blades are constructed of wood, reinforced with metal spars. A four-cylinder engine of 55 hp is mounted in the

Horse (YAK-24) is shown with underslung surveying camera.

Hound (MI-4) light transport can carry 15 troops.

forward position with the pilot sitting astride the rotor shaft. It features a compressed-air starter.

The versatile helicopter Hen, is a light, all-metal, two-place machine with two 3-blade, coaxial, counterrotating rotors. The Hen was developed from the Hat; is suitable for a wide variety of military and civil duties including observation, liaison, medical evacuation, spraying and dusting, and rescue work. Special containers for stretcher patients, collapsible life rafts, and spraying chemicals can be attached to the side of the fuselage. Powerplant is located in the center of the fuselage and consists of a special vertically-mounted version of the same reciprocating engine used in the Creek, fixed-wing utility aircraft. Hen's rotor blades are constructed of wood and plastic. A quadricycle landing gear is used composed of two small nosewheels with knee-action suspension, and two main wheels, each supported by three struts slightly behind the engine section. Side-by-side seating is provided in the cabin which has sliding access doors on each side.

Utility Helicopters—The Hog is a 4-place helicopter derived from the 2-place Hen. It has three-blade, coaxial counterrotating rotors and a twin vertical fin and rudder assembly. A four-wheel landing gear is used. It is presumed that cargo or extra fuel tanks can be carried externally below the fuselage of the Hog as can be done with the smaller Hen. Engine of the Hog is located aft of the main rotor shaft just behind the cabin. The main advantages claimed for this type are: (1) Simplified control—a change of collective pitch does not necessitate a compensating adjustment of the rudder pedals and cyclic control stick; (2) a 15 per cent increase in range due to the lower disc-loading on each rotor; and (3) a smaller and more symmetrical aircraft. The main disadvantage is vibration due to the long, thin shaft which turns the upper rotor.

The Hare helicopter is a conventional Soviet machine designed for reconnaissance, liaison, and utility purposes. Its fuselage, constructed of steel-tube framework, has a metal covering. Its 7-cylinder, radial engine is mounted horizontally in the center of the fuselage with the fuel tank directly behind. The Hare utilizes a compressed-air starter. Both the main and tail-rotor blades are of wood, metal, and fabric construction with provisions for a fluid anti-icing system. A tricycle landing gear is used with oleo-pneumatic shock absorbers and a fully castoring nosewheel.

Transport Helicopters — The Hound is a light transport type capable of carrying up to 15 troops. The large appendage under the fuselage could serve as a navigator's/observer's gondola, as a container for photographic or radar equipment, or as a firing site for guns or rockets. Hound's radial engine is mounted in the nose of the fuselage and is equipped with both electric and manual inertia-starters. Main rotor blades which are equipped with fluid de-icing equipment can be folded when aircraft is stored in confined areas. Main fuel tank is located directly behind the main rotor shaft in the upper part of the fuselage; an auxiliary tank can be installed in the cargo compartment. Bulk loads such as GAZ-69 command car or a 76-mm field gun can be loaded through clamshell doors aft of the fuselage. The cargo compartment dimensions are: length, 13 ft 7 in.; width, 5 ft 7 in.; and height, 5 ft 11 in.

Flying Boxcar—Medium transport-helicopter the Horse is called "Flying Boxcar" in the Soviet Union. This is a tandem-rotor helicopter powered by two 14-cylinder radial engines driving two 4-blade rotors. An interconnecting shaft between the two engines synchronizes the rotors and assures continued power to both rotors if one engine fails. Both engines are accessible from inside the aircraft for inspection during flight. Fuselage of the Horse is constructed of metal framework with metal covering. In the early models the center section was covered with fabric. Oleo-pneumatic shock absorbers are used on the quadricycle landing gear. Originally the Horse had "V" tail stabilizers, but later versions have near-vertical fins. The horizontal stabilizer is probably trimmable as is the

SOVIET HELICOPTER SPECIFICATIONS

Identification					Powerplant				Dimensions			
NATO NICKNAME	Soviet Designation	Year Built	Designer	Type	No. Engines	Engine Designation	Type	HP Rating (take-off) (per engine)	Height (in.) (max.)	Over-all Length (ft) (excluding rotors)	Rotor Diam. (ft)	Tail Rotor Diam. (ft)
Hat	KA-10	1948	Kamov	O	1	AI-4G	4-cyl, air cooled	55	98	12.8	20	.....
Hen	KA-15	1955	Kamov	O	1	AI-14V	9-cyl, radial	250	120	.....	28	.....
Hog	KA-18	1957	Kamov	U	1	AI-14V	9-cyl, radial	250	130	27.2	32.5	.....
Hare	MI-1	1951	Mil	U	1	AI-26V	7-cyl, radial	575	130	55.5	47	8.2
Hound	MI-4	1952	Mil	LT	1	ASh 82V	14-cyl, radial	1675	173	55	69	11.8
Hook	MI-6	1958	Mil	HT	2	TV-2VM	Shaft Turbine	4700	624	157	148	28
Horse	YAK-24	1954	Yakovlev	MT	2	ASh 82V	14-cyl, radial	1675	252	72.2	65.5	.....

ABBREVIATIONS: O—Observation; U—Utility; LT—Light Transport; HT—Heavy Transport; MT—Medium Transport.

rudder - type trim tab aft of the horizontal stabilizers and twin fuselage.

Fully glazed crew compartment of the Horse accommodates a pilot and co-pilot, a flight engineer, and a radio-navigator. Various heavy items of equipment such as three M-20 Pobeda staff cars, or one command vehicle and field gun can be loaded aboard, through a hydraulically-operated ramp-door in the rear of the up-swept tail assembly. There is also a sliding door approximately 4 x 6 ft on the port side of the fuselage for passenger entry. Cargo compartment of the Horse measures 33 x 7 x 6.5 ft.

Weight - Lifter — Intended for heavy transport, the Hook is a large all metal helicopter powered by two shaft turbines. Called "Bruin" in the USSR, this machine in October 1957 set a new load-to-height record by lifting 26,464 lb to 7874 feet. The Hook's shaft-turbine engines lie horizontally at the top of the fuselage with air intakes above the cockpit. Each engine is said to have two independent turbines, one to drive the compressor, the other to drive the rotor through a reduction gear. Such an arrangement eliminates the need for a complex clutch. It has been suggested that the powerplant and the rotor comprise a self-contained unit to which could be attached a variety of fuselages or structures suitable for "flying crane" applications.

In the rear of the Hook's cabin are hydraulically-operated clamshell doors and a ramp, permitting rapid loading or unloading. Small doors on both sides of fuselage provide additional access to the cabin and pilots' compartment. Navigator's compartment is located in the glass-paneled nose. The tricycle landing gear features oleo-pneumatic struts, dual wheels on the nose gear, and wheel pants on the main gear. Cargo compartment measures 62 x 13.6 x 9.8 ft.

Implications — All these Soviet helicopters, with the exception of the single-seat Hat, are in production either in a military or civil version. This is a substantial achievement, reflecting both the high-priority assigned to helicopter development and the rapid progress achieved in helicopter production during the past decade. That this priority had the necessary financial support is demonstrated by the development

Hen (KA-15) is light, two-place, observation helicopter.

Hog (KA-18) 4-place helicopter serves utility purposes.

SOVIET HELICOPTER SPECIFICATIONS

Weights and Capacities						Performance					Fuselage			Rotor Configuration	
Empty Wt. (lb)	Gross Wt. (lb)	Crew	Fuel (gal)	No. Passengers	Cargo Capacity (lb)	Max. Speed (kt)	Cruising Speed (kt)	Cruising Range (Naut. Miles)	Rate-of-climb (fpm)	Service Ceiling (ft)	Length (ft)	Width (in.)	Height (in.)	No. Blades Per Rotor	Arrangement
550	825	1	8.3	.....	.....	65	60	100	600	8000	.....	.....	.....	3	Coaxial counterrotating
1825	2534	1	50	1	200	85	65	230	.....	9840	16.5	48	55	3	Coaxial counterrotating
2000	3100	.....	.....	3	440	85	65	240	.....	9800	.....	.....	.....	3	Coaxial counterrotating
3927	4950	1	.....	2-3	350	100	75	210	.....	16,400	40.7	55	91	3	Single main and tail rotor
11,288	16,610	.....	264	15	3300	110	75	240	.....	18,000	.....	.....	.....	4	Single main and tail rotor
45,578	75,200	3	1500	70	20,000	140	110	250	.....	16,000	157	180	276	5	Single main and tail rotor
21,000	34,000	2-4	533	40	8800	110	85	140	.....	13,500	72.2	96	96	4	Tandem rotors

ABBREVIATIONS: O—Observation; U—Utility; LT—Light Transport; HT—Heavy Transport; MT—Medium Transport.

of successful helicopters utilizing three different types of rotor systems. It is well known that the major cost in helicopter development is in the rotor and powerplant systems.

Paralleling the development of the helicopter, the Soviet Army in the past decade has placed special emphasis on improving its airborne techniques and capabilities. Training has been intensified, and the air transportation capability has been improved materially by the adoption of helicopters. It can be expected that in any future Soviet military action the helicopter will play an important role not only as a transport vehicle but also as a fighting vehicle armed with guns and rockets.

Finally, how do these Soviet helicopters compare with United States helicopters? This is not easily answered, for national military and civil concepts and requirements differ. For example, Soviet development and production of the Hook, which is the world's largest helicopter and for which there is no United States equivalent, reflects a Soviet requirement for a single transport vehicle capable of airlifting up to 10-ton loads. The United States, on the other hand, fulfills this small requirement by using a different mode of transportation or by utilizing two or more smaller and less-expensive helicopters carrying specially-designed packages or components which are equivalent to a 10-ton load. With this difference in mind, it can be said that in terms of operating helicopters, the USSR is probably about equal to the United States. In terms of the overall state-of-the-art, the United States with its wide diversification and short-take-off-and-landing aircraft, probably is ahead of the USSR in research and development. The U.S. advantage is, however, slight. Under present world conditions the United States cannot afford to lose this advantage.

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Hare (MI-1) serves recon, liaison, and utility duties.

MIL's crane carries prefab house during Tushino air show.

★ ★ ★ MISSION FOR MILITARY MANAGEMENT

Making Defense Dollars Do More

★ ★ ★ by RADM Paul D. Stroop, USN Chief, Bureau of Naval Weapons

- *Each year, more money buys less defense hardware.*
- *Navy is attacking rising costs with new management techniques.*
- *Cost saving programs have resulted in:*
  - *(1) Reduction of $9700 on each Sidewinder.*
  - *(2) Elimination of $7.5 million maintenance on Bullpup.*
  - *(3) Cut of $1.04 million on torpedo tube costs.*
  - *(4) Over $1.24 million reduction on ASROC costs.*
  - *(5) About $1.0 million cut in Polaris fire control and guidance.*

The largest management problem the free world has ever known is that of running a bewildering defense complex in this age of technological explosion and spiralling costs. But, the Department of Defense "businessmen" has this staggering job.

The Navy now has assets of about $70 billion. Daily spending is over $30 million. Its assets approach those of the 100 largest corporations in the United States. In the BuWeps, the Navy has one of the largest technical and industrial complexes in the country. It is certainly, the largest single organization in the Department of the Navy. Of the total annual Navy appropriation, approximately $11 billion of dollars, the Bureau takes $4.5 billion—roughly 40 per cent. Our research and development of aircraft and weapon systems accounts for about 70 per cent of the total Navy R&D funds.

Unfortunately, there is presently no alternative to heavy expenditures for defense. Advanced management techniques, and cost saving programs are therefore among our basic planning requirements.

Cost Trends—To give an idea of what the Navy is up against, let me review the cost trend which gives rise to so much concern in aircraft and missile programming. Let's look at aircraft costs, because the aircraft trend covers a longer span of time than missiles. When aircraft were procured in large quantity (WWII), naval airframe costs averaged $9 per pound. When World War II ended, aircraft production quantities declined drastically and airframe cost immediately doubled. By 1947 cost hit $19 per pound. Despite radical fluctuations in both quantity and mix through the intervening years, one startling fact emerges. Each year airframe costs per pound have increased steadily. In 1960 they hit a new high of $110 per pound. This is over twelve times the World War II average, and over four times the 1950 pre-Korean average.

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"Each year it costs more to operate a slowly shrinking Naval establishment."

Admiral Arleigh A. Burke

★ ★ ★

Rising costs are causing a reduction in the number of aircraft operating with the fleet. Navy should buy 1200 new aircraft each year just to stay even at 7200.

Effect on Aircraft—What effect has the cost trend had on size of the Naval establishment? Admiral R. B. Pirie, DCNO (Air), says that naval airpower will drop below 6800 aircraft by the end of 1961, a reduction of approximately 400 aircraft from the 7200 operating aircraft program in 1960, and almost 3000 less than in 1957.

"This reduction results from two factors," Admiral Pirie points out. "First, we have bought only a limited number of new aircraft since 1958. The average number of new aircraft bought each year, approximately 650, will not support an average aircraft operating program of 7200," he said. "Based on our gains-against-loss experience tables, the average useful life of a modern aircraft is 5 years. This means that 20 per cent of the operating inventory should be replaced each year if a level operating program is to be maintained. To maintain 7200 operating aircraft would require a yearly buy of about 1200 new aircraft. Second, he feels some reductions . . . have resulted from decommissioning of units which can no longer be supported under the share of funds allocated to operating aircraft.

Admiral Pirie goes on to explain the numbers of operating combat aircraft have not been decreased from the end of fiscal 1959 up through the end of fiscal year 1961. He says Navy avoided reductions to combat units at all costs in fiscal 1961. We are now cutting support areas to the bare bone. The lighter-than-air operations started a complete phase-out in June 1961. Pilot training rate has been drastically reduced; desirable but non-essential units have been decommissioned, and indirect support aircraft have been reduced in the proficiency flying and logistic support areas. Of the 6791 aircraft operating on June 30, 1961, 3504 are combat aircraft, 1263 other aircraft will be assigned to the pilot training program and 784 to the reserves. "This leaves a pretty thin support level," Admiral Pirie said. Unless additional aircraft can be bought each year, some reduction in combat aircraft operating numbers will have to be made subsequent to fiscal year 1961.

Getting More Per Dollar—How can we slow down this attrition within our restricted funding? To a degree, we can do so by attempting to get more for our dollars. This is the mission of those of us working at business management in the Bureau of Naval Weapons. To make ends meet and get the best possible weapons for the Fleet we must do several things:

First, we must accept the idea of change—rapid change. The merger of the old Bureaus of Aeronautics and Ordnance into the Bureau of Naval Weapons symbolized the merging paths of the piloted aircraft, the satellite, the guided missile, bomb, rocket, bullet, and homing torpedo. It also reflected the changing climate of our time. The purpose of the merger was primarily to speed the flow of missiles to the Fleet. It was to cut down on the lead time required for development. It was to improve reliability and performance. It was to accomplish all of these at least cost.

Continuing Objective—I have resisted the establishment within the Bureau of a special "cost reduction" program, as such. To me cost reduction has been, and is, a continuing Bureau objective similar to high performance, or reduced lead time. Value buying is not new.

But, since BuWeps was established we have instituted many advanced management programs. For instance, the Bureau's system of strong Program Management through which autonomous program directors plan, coordinate and direct

all functional activity in support of Bureau programs, is a most significant advancement contributing to reduction of lead time. Our program directives system, supported by a report account structure responsive to the needs of total integrated program management, provides us close control of the application of funds. The system is directly effective in balancing available funds with greatest needs.

Quality Control—We have recently delved further into the subject of quality control. We are shifting quality control orientation from control of production and conformance to specifications, to a research and development emphasis. Reliability must be designed into the weapon. We cannot afford to redesign each weapon to achieve the required reliability. Reliability engineering properly applied in the design phase will result in reduced fleet maintenance and logistic costs, redesign during prototype production, and drastically reduced number of change orders and alterations presently required to maintain weapons systems operational.

Executive Meetings—As effort to meet the challenge of technological advancement and the inevitable higher costs, I have instituted a program of personal, frank discussions with top executives of major Bureau contractors to create a healthier and more constructive climate for vigorous Navy/industry cost reduction efforts. One significant action taken by the Bureau is the attempt to reach firm prices earlier in production programs. This stimulates greater cost consciousness in the planning of our contractors.

We continually ask ourselves, in BuWeps, "are we getting our money's worth?" In most cases, the answer is unequivocally, yes. However, as a result, we have eliminated some items which did not seem to offer as much return for our money. The RAT (Rocket-Assisted-Torpedo) ASW weapons system was one of these. We have also closed out the promising long-range Regulus II, the air-to-air Corvus missile, and the F8U-3 Crusader development, and the Eagle to make more money available in projects bearing higher priority.

Maintenance—In all our modern weaponry, one of the cost factors that gives us great concern is maintenance. We are giving a great deal of thought and effort to the design of weapons which will require little or no maintenance in the field. The Bullpup missile, which has more than met its original requirements, is one of these weapons. We eliminated field checkout and test procedures. This was possible because of the relative simplicity of the Bullpup design and the high quality of the components used. Elimination of these tests will save the Navy more than $7,500,000 during this first year.

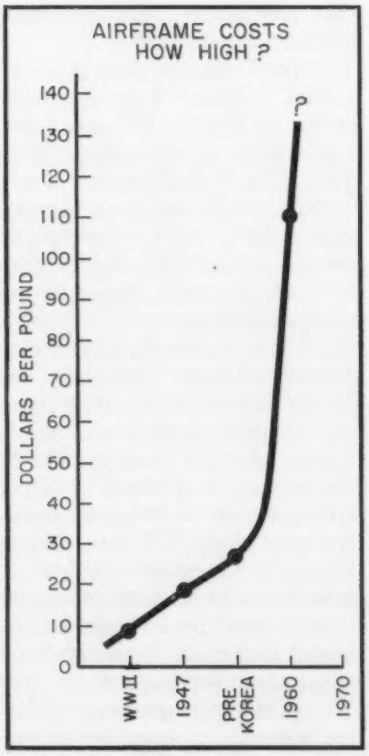
Again, during Sidewinder development, our principal tenet was simplicity and low cost, with little or no maintenance in the field, and the minimum of training. This air-to-air missile is fully operational in the Fleet today. It also is being used not only by our own Air Force, but also by the Air Forces of several friendly nations. The volume of production permitted us to put two companies in competition with each other and they have gotten the "fireaway" costs down from the 1955 figure of $11,000 to a more economical figure of $2300 each.

Reduce Changes—Early in 1958 BuAir sought to reduce engineering cost by imposing rigid controls on aircraft changes. These controls, now extended to weapons systems, have been so effective that engineering change proposals (ECPs as we call them) have declined in less than three years from more than 250 per month to only one-tenth that level. We take great pride in the fact that our ECP rate is now down to an unprecedented low level of 25 per month.

Wants vs. Needs—Inasmuch as research and development serve as the bridge between our current weapon systems and those that are to come, our plans must be geared to our future capabilities. Our hope for survival in a chaotic world depends upon our store of ever growing scientific knowledge. Nevertheless, we continually strive for a proper balance between our "must have today," and what we must develop for tomorrow. In our procurement planning the aim is to buy wisely and to encourage competition.

Value Buying—Our contractors are considered an integral part of the BuWeps "value improvement" team. Value buying policies, sound decisions, effective procedures and controls must be worked out through agreements with the vendor and all depends on contractor performance.

In the Bureau, we are working to eliminate unnecessarily costly and rigid specifications and to make the maximum possible use of industry specifications. We are reviewing the need for design documentation



with the idea of reducing it to an absolute minimum. The potential here for savings has been demonstrated by one of our contractors who has cut down his paper work by more discriminating use of drawings. The resultant savings is about $2 million, and the conservation of scarce engineering talent.

The field of contracting is one of the major facets of value improvement.

The Bureau's contractual approach is based on the premise that substantial cost reductions can be obtained by providing realistic and attractive incentives to our contractors as an inducement for conducting vigorous analyses for dollar value.

Two Step Program — We use two basic approaches:

First, a contract provision establishes value improvement as a line item in a contract, at an agreed price, at the outset of the contract. Generally this approach is adaptable to procurement of an R&D or an evaluation nature, and serves as a supplemental undertaking to the development project. Thus, the cost reduction can be accomplished in the initial stages before the item goes into mass production, making possible the savings of substantial dollars.

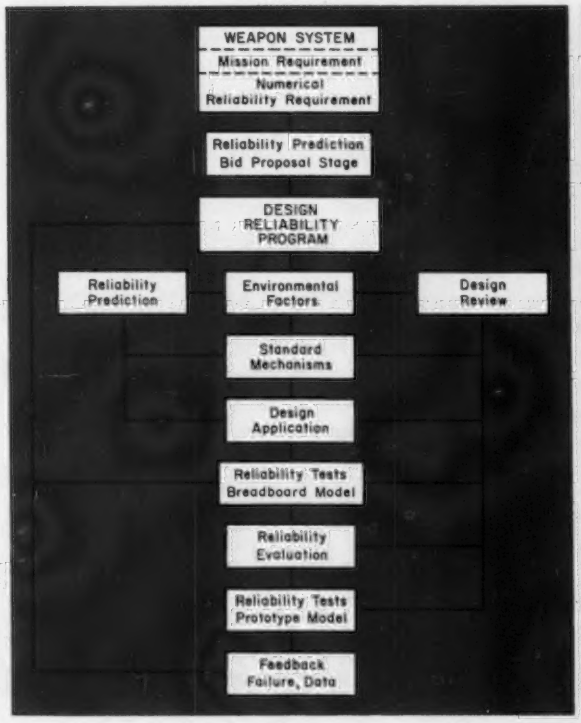
The second, and perhaps the most frequently used contractual approach adopted by the military services, provides for the contractors to engage in a dollar-value analysis under a contract in exchange for a share in the cost savings generated by value improvement proposals adopted by the Bureau contracting officer. Primarily, this method has application to production type procurements. In its operation, the contractor submits value improvement proposals, suggesting modifications to specifications and designs requiring contracting officer approval, which will result in less costly articles without adversely affecting the functioning quality and reliability of such articles. Compensation to the contractor is derived by a percentage share determined at the outset of the contract, which is applied against the cost savings negotiated under each value improvement proposal adopted.

Value improvement clauses variously known as value analysis or value engineering, were included in BuAer and BuOrd contracts beginning in early 1959. They already have been incorporated in a number of BuWeps contracts. Many of the future aircraft and missile systems contracts will include this new management tool for cost saving.

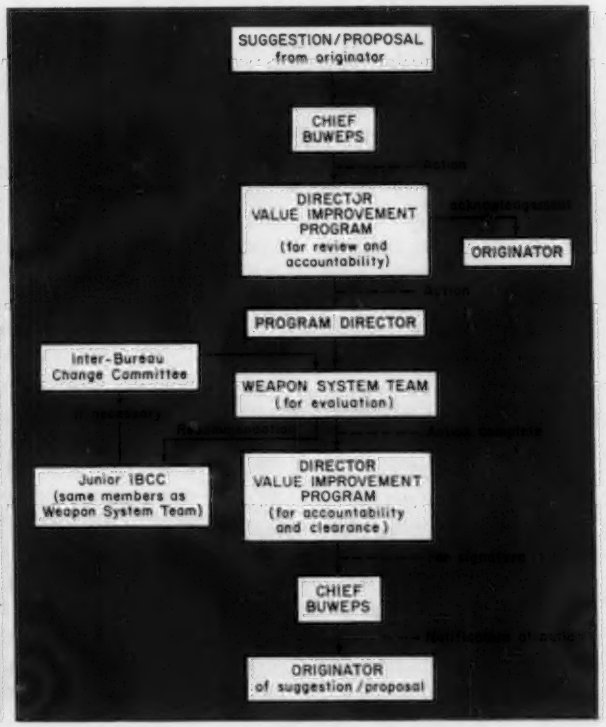
Subcontract Costs—Another obvious point for attack on high aircraft and missile costs is the subcontracting field. It presently accounts for one out of every five dollars spent by primes. We are asking our prime contractors to re-evaluate their major component "make-or-buy" decisions from a cost standpoint; to broaden their competitive base in subcontracting by finding additional sources; and to broaden their use of incentive features in contracts to subs.

Heretofore, value engineering was applied primarily as a "second look" during the production phase. As time goes on, we expect to expand our value engineering effort more and more in the concept, design, research and development

DESIGN RELIABILITY FLOW CHART



COST SAVINGS FLOW CHART


SUGGESTION/PROPOSAL from originator
CHIEF BUWEPS
DIRECTOR VALUE IMPROVEMENT PROGRAM (for review and accountability)
ORIGINATOR
PROGRAM DIRECTOR
Inter-Bureau Change Committee
WEAPON SYSTEM TEAM (for evaluation)
Junior IBCC (same members as Weapon System Team)
DIRECTOR VALUE IMPROVEMENT PROGRAM (for accountability and clearance)
CHIEF BUWEPS
ORIGINATOR of suggestion/proposal

phases, when value improvements are not burdened by amortization costs for expensive changes in drawings and tooling. We are including value engineering in the development of many of our newer weapon systems. Nevertheless, even with the higher cost of putting the proposals into effect the cost reductions realized by applying value engineering during our current production programs have still been appreciable, as can be shown by citing some examples.

Leaving Things Out—Thinking of leaving things out, rather than putting things in, eleven value engineering changes, ranging from $1.75 to $362.00 per change, reduced the unit cost by $1152 on our triple-barrelled Torpedo Tube MK 32 for surface ships. This is a 9 percent reduction based on the original cost of $13,000 per tube. Attendant benefits include the elimination of approximately 300 parts, which contributed to improved reliability and simpler, lower cost maintenance. The cost of the value engineering effort was $27,000. On current production orders, these changes produced a cost reduction of $291,000. On the total planned procurement of 900 tubes, we expect a cost reduction of $1,035,000.

Cut $1.66 Million On J-79—Since the beginning of production on the J-79 turbojet engine, powering both the F4H Phantom II and the A3J Vigilante, a total of 157 value engineering projects has been initiated. These included substitution of material, use of standard items, tooling improvement, elimination of components, and extensive review of requirements. These and other types of changes allowed the manufacturer to reduce costs by $1,665,000 in the initial three years of production of the J-79 turbojet engines. This is an average saving of more than $10,000 for each of the 157 value engineering projects. This figure is even more impressive when it is considered that under the manufacturer's ground rules, the dollar credit in cost reduction for any particular year includes only those value proposals initiated during that year, and is not cumulative for succeeding years.

While it is hard to distinguish between wants and needs, continuing efforts reduced the costs of ten parts of the Sidewinder missile. These efforts included the re-evaluation of certain requirements which led to design changes, material changes, process changes, and manufacturing simplification. In a recent procurement, these permitted a cost reduction of $429,000.

Analysis of the original requirements for local control against aircraft and surface targets eliminated an $18,000 telescope from each of our 5 in./54 gun mounts. In the cost of recent deliveries, this achieved a total reduction of $684,000.

Polaris Savings — The actual and potential cost reductions by using value improvement in the fuzing, fire control and guidance systems of the Polaris ballistic missile are already over the $1 million mark. Out of a total of 103 cost reduction proposals made by the contractor, 62 were incorporated in the system, with 29 more pending review and approval. Typical of the value work are the minimizing of machining, use of off-the-shelf items, modifying designs, changing materials, eliminating parts and manufacturing processes, and simplification by utilizing molded parts or investment casting.

To give one example, from the Polaris Fire Control System, a maintenance test module, approximately 4 x 6 x 10 in., was reduced in cost from $367 to $104 by: (1) eliminating three printed wiring boards, brackets, 104 solder joints, wiring, fasteners, and related tooling; (2) simplifying the construction of the chassis and the electrical circuitry and the related tooling; and (3) facilitating assembly.

These and other changes reduced the weight of each module by 40 percent and improved the reliability and maintainability. There are twenty-four of these modules in each fire control system, therefore resulting in a total net cost reduction of $6300 per system. All the value engineering recommendations accepted so far have produced handsome advantages, including reduced weight and increased reliability, both factors of vital importance.

ASROC Savings — We have found that the concept of value engineering effort to reduce costs, even in a very limited study, has also produced handsome dividends in the ASROC launcher program. In the Launcher Captain's control panel alone, one of our Naval Ordnace Plants achieved a cost reduction of over $15,000 and a weight reduction of 700 pounds per launcher, with improved reliability and maintainability.

Three proposals to either eliminate components entirely or replace them with simpler, equally functional mechanisms, made so much space available that three panels originally costing $27,000 per set were integrated into one console. These and five other proposals effected so far are expected to result in a net cost reduction of $1,248,000 in the fiscal year 1962 procurement.

Costly Practices—There may be and probably are many requirements imposed by the Bureau which add unnecessarily to procurement cost, and these requirements must be discarded as rapidly as we can single them out for action. Here we must depend upon our industry partners to be of incalculable assistance by pointing out these requirements together with the higher costs they generate. Our goal, let me emphasize, is to channel our efforts in such a manner that the public gets all that it pays for.

✦

A SINGLE REPRINT of this article is available as long as the supply lasts. Write on company letterhead to: Editor, AEROSPACE MANAGEMENT, 56th & Chestnut Sts., Phila. 39, Pa.

NEW Products at WESCON

Be sure to visit AEROSPACE MANAGEMENT at booth No. P-17

Aircraft Test Set

Model 4B, on display, incorporates in one instrument a means of measuring frequency as well as AC and DC voltages. In addition to electronically measuring frequency and usual multi-testing operations, a 115/208 volt phase checker for sensing the "dim" and "bright" phases in aircraft wiring systems is included. — *Airpax Electronics, Inc., Booth No. 1716*

Circle 170 on Inquiry Card for more data

Hi-Speed Switches

Series of silicon NPN epitaxial high speed switching transistors that feature faster switching speeds, high breakdown voltages, low saturation voltages, and low output capacities, will be on display.—*National Semiconductor Corp., Booth No. 4212*

Circle 171 on Inquiry Card for more data

Magnet Wire

New line of Netic, Co-Netic AA and Co-Netic B alloy wires with high permeability offer a lower reluctance path to the magnetic flux concentrating the field in transformer and other inductance applications.—*Magnetic Shield Div. of Perfection Mica Co., Booth No. 4606*

Circle 172 on Inquiry Card for more data

Horizon Sensors

Series 13-160 sensors are compact and sensitive infrared scanning instruments, which can detect thermal discontinuity by employing germanium-immersed thermistor detectors.—*Barnes Eng. Co., Booth No. 1308*

Circle 173 on Inquiry Card for more data

Parts Cleaner

Precision Cleaner, model RT-S-8-6, cleans switches, relays, choppers, semiconductors, and other precision components at the rate of 600 units per hour. Components are loaded into fixtures around the periphery of a rotary turntable that introduces the components to successive high velocity spray-clean operations.—*Cobehn, Inc. Booth No. 4824*

Circle 174 on Inquiry Card for more data

Gain Set

Gain set designed for use in measuring gain, loss, noise figure and many other transmission characteristics of systems and components in the UHF, VHF and microwave regions will be on display. — *Kay Electric Co., Booth No. 3105*

Circle 175 on Inquiry Card for more data

Transistor Socket

Display Model XS-T4 has the following features—closed entry socket contacts, silver plated beryllium copper contacts, accessible contact tabs and clearly identified contacts.—*Pomona Electronics Co., Inc., Booth No. 2709*

Circle 177 on Inquiry Card for more data

Long Life Battery

Display includes a silvercel battery that is said to have achieved more than 440 cycles during 30 months of operation. Long life feature should prove useful in many applications.—*Yardney Electric Corp. Booth No. 3402*

Circle 178 on Inquiry Card for more data

Self-Sealing Fasteners

New line of captive screws that incorporate silicone O-rings for pressure sealing applications up to 500 psi. Screws employ a grip ring on the blind side of the panel as a retaining device.—*A.P.M. Corp. Booth No. 2614*

Circle 179 on Inquiry Card for more data

Instrument Packaging

Featured in this exhibit will be 22 instruments presented in a new line of modular enclosures. The modular instruments may be used as either bench or rack models.—*Howlett-Packard Co. Booth No. 2313*

Circle 180 on Inquiry Card for more data

Electronics Welder

New welder designed for production and laboratory fabrication of electronic subassemblies and system packages. Unit requires no adjustment of electrodes, heads or power setting, available with either vertical or pincer type plug-in heads.—*Sippican Corp. Booth No. 4422*

Circle 181 on Inquiry Card for more data

Humidity Chamber

Equipped with a 16 in. dia. chamber 14 in. deep these units were designed to meet Mil-202B. Display will also include refrigerated baths, oil baths and environmental cabinets.—*Blue M Electric Co. Booth No. 5112*

Circle 182 on Inquiry Card for more data

Ultrasonic Cleaning

A new line of fully-transistorized ultrasonic cleaning systems designed for use in the space age metal fabricating and electronic components industries. Booth personnel will clean visitors eye-glasses, rings and watchbands. — *Acoustica Associates, Inc. Booth No. 1407*

Circle 183 on Inquiry Card for more data

Switch Display

Display will include a new line of multi-deck thumbwheel switches, binary switches and rotary selector switches.—*Chicago Dynamic Industries, Inc. Booth No. 1112*

Circle 184 on Inquiry Card for more data

Extensible Cable

New cable consists of two multiconductor, helical wound cables, one wound inside the other and spiralling in opposite directions. This results in a flexible assembly with a high power of retraction. — *Spectra-Strip Wire & Cable Corp. Booth No. 4726*

Circle 185 on Inquiry Card for more data

One Watt Transceiver

New, all transistorized, light weight hand held transceiver with special noise quieting features and a re-chargeable battery will be shown and demonstrated. — *Osborne Electronics Corp. Booth No. 612*

Circle 186 on Inquiry Card for more data

Feedthrough Collars

Vacuum system collars that allow easy access to evacuated systems for high and low voltages, currents, cooling water, RF heating and gauges.—*Vacuum Technology, Inc. Booth No. 1214*

Circle 187 on Inquiry Card for more data

Data Presentation

A display console which is an electronic inquiry station that converts coded electrical signals from any random access-type memory unit

NEW WESCON Products

continued

into readable letters, numbers, and symbols and displays them on a 14 in. television tube.—*A. B. Dick Co. Booth No. 117*

Circle 188 on Inquiry Card for more data

Moldable Dielectric

New ceramoplastic, called Supramica 620, will be displayed. This material should be of interest to engineers and designers for it will operate at up to 1200°F.—*Mycalex Corp. of America. Booth No. 902*

Circle 189 on Inquiry Card for more data

Pressure Potentiometer

New miniaturized, model P105, pressure pot weighs less than 4.5 oz and measures only 2 in. in length. Unit will measure pressure between the range of 0-10 to 0-350 psi.—*Trans-Sonics, Inc. Booth No. 4414*

Circle 190 on Inquiry Card for more data

Frequency Generator

New crystal controlled microcircuitry frequency generator weighing 1.75 ounces and measuring 1.3 cubic in. in volume will be featured.—*Varo, Inc. Booth No. 3609*

Circle 191 on Inquiry Card for more data

Clutch Cluster

Function potentiometer clutch cluster assembly consists of four clutch-brake/ganged potentiometer assemblies coupled to a common drive shaft and housed in an enclosed container. Unit obtains output information which is in accordance with a prescribed highly non-linear mathematical function.—*Technology Instrument Corp. Booth No. 1506*

Circle 192 on Inquiry Card for more data

Klystron Power Supply

New, compact, portable instrument designed to operate low power klystrons. New unit is said to have improved reflector voltage resolution and low ripple.—*PRD Electronics, Inc. Booth No. 2109*

Circle 193 on Inquiry Card for more data

Plug-In Diode

Featured in this display will be a diode designed for use in computer logic microcircuitry. Unit consists of up to five separate diode junctions, each with an individual lead, formed on a single silicon slice in a computer gate configuration.—*Delta Semiconductors, Inc. Booth No. 4512*

Circle 194 on Inquiry Card for more data

Miniature Recorder

New circular chart recorder that requires no pen, ink or ribbon. Graph is recorded on a 3 in. dia circular chart made of pressure sensitive paper, as the stylus moves over the white chart a black line is recorded. Unit will record variables such as voltage, power, temperature or pressure.—*Thomas A. Edison Industries. Booth No. 718*

Circle 195 on Inquiry Card for more data

Circuit Connectors

New line of printed circuit connectors provides two sets of twin receptacles to accommodate 1/16 in. circuit boards. Unit has a total of 140 terminations divided into two sets of 38 and 32 contacts.—*Viking Industries, Inc. Booth No. 1815*

Circle 196 on Inquiry Card for more data

Destruct Receiver

New command destruct receiver/decoder package for missiles. Interlocked decoder provides a destruct signal when three tones are received in a predetermined combination and sequency.—*R S Electronics Corp. Booth No. 3322*

Circle 197 on Inquiry Card for more data

Block Modules

New series of digital plug-in cards, FD series, and block modules, FM series that operate at 10 mc over a temperature range of from −50 to +100°C. With a variety of circuits available it will be possible to assemble any size computer that will operate at 10 mc in either a ground or missile environment.—*Delco Radio Div. of General Motors Corp. Booth No. 2518*

Circle 198 on Inquiry Card for more data

Carbon Pot

New pot designed to provide electrical quietness needed in better grades of commercial equipment. Unit designated series 63M will be available in a variety of resistance values.—*Clarostat Mfg. Co. Booth No. 1714*

Circle 199 on Inquiry Card for more data

Assembly Devices

Featured in this display will be "POP" blind rivets for use in fastening and assembly applications in the electronics industry. Also on display will be machines made for the semi-automatic placement of components in electronic assemblies.—*United Shoe Machinery Corp. Booth No. 4722*

Circle 200 on Inquiry Card for more data

Diode Tester

Model to be shown is designed for production testing, engineering analysis, quality control and incoming inspection of diodes and rectifiers.—*Atlantis Electronics Corp. Booth No. 4508*

Circle 201 on Inquiry Card for more data

Statistical Computer

Computer for determining reliability and parametric scatter in missile components. Mean value and standard deviation are readable on up to 99 items per class in 10 classes.—*Boonshaft and Fuchs, Inc. Booth No. 4503*

Circle 202 on Inquiry Card for more data

Capacitor Tester

Automatic test set for tantalum and other high value capacitors incorporates a high sensitivity detector for low voltage measurements. Reading locks after balancing and the sample can be removed without loss of reading.—*Barnes Development Co. Booth No. 3305*

Circle 203 on Inquiry Card for more data

Instant Insulation

Diode and transistor cases can be insulated quickly with a number of plastic materials that are cut to size. The formed sleeve, or preform, is slipped over the case and then made permanent by applying heat which shrinks the plastic to conform with the case.—*Rayclad Tubes, Inc. Booth No. 5008*

Circle 204 on Inquiry Card for more data

Industrial Laminates

A line of recently developed laminates for critical electronic applications such as missiles, radar, aircraft and ground instruments. Featured in the display will be a copper clad laminate that is said to be able to withstand severe thermal and mechanical shock.—*General Electric, Laminated Prods. Dept. Booth No. 4811*

Circle 205 on Inquiry Card for more data

Microfilm Televiser

Microfilm readout device tied to a closed circuit television which allows a drawing or print to be enlarged as much as 300 x will be on display.—*GPL Div. of General Precision, Inc. Booth No. 3309*

Circle 206 on Inquiry Card for more data

Slip Ring Assembly

New self-contained assembly designed for instrumentation applications will be on display. Unit available in 4, 8, 12, 16, 20, 24, 28 or 32 circuit configurations.—*Fabricast, Inc. Booth No. 1307*

Circle 207 on Inquiry Card for more data

Coil Winding Machines

Display will feature the model S winding machine that incorporates a completely transistorized counter. This is the first time an "in line digital read out" counter has been used with a toroidal winding machine.—*Universal Mfg. Co. Booth No. 4532*

Circle 208 on Inquiry Card for more data

NEW LITERATURE

Worth Asking For

Foreign Markets

"Doing Business In Italy" is a reprint of the speeches delivered at the orientation seminar on "How to do Business in France and Italy." Booklet deals with investment opportunities, banking systems and taxation problems.—*Italian Embassy*

Circle 209 on Inquiry Card for more data

Hydraulic Power & Control

Booklet offers a complete listing of this company's line of industrial hydraulic power and control devices. —*Vickers Inc.*

Circle 210 on Inquiry Card for more data

Limited War

A 24 page pamphlet dealing with the role that planning and analysis plays in meeting the challenge of limited war. — *Planning Research Corp.*

Cirrle 211 on Inquiry Card for more data

Ground Support Equipt.

Brochure deals with the services offered in the engineering and production of ground support equipment.—*Genistron Inc.*

Circle 212 on Inquiry Card for more data

Facilities—Capabilities

Booklet describes facilities offered for engineering design and drafting of aircraft and aircraft modifications including system and componetry work.—*Air-mod Engineering Co.*

Circle 213 on Inquiry Card for more data

Personnel Facts

Brochure describes the methods of minimizing errors in the selection of personnel and executive level promotions through phychological testing. Facts included have been drawn from the testing of executives, engineers, supervisors and salesmen.—*Personnel Psychology Center*

Circle 214 on Inquiry Card for more data

Emergency Report

Report deals with the effects of metal damage caused by improper grinding of high-strength aircraft fasteners. — *Standard Pressed Steel Co.*

Circle 215 on Inquiry Card for more data

Solid Propellant Motors

Information dealing with chemical propellants and rocket motors is offered in a twelve page booklet.—*Hercules Powder Co.*

Circle 216 on Inquiry Card for more data

Products Booklet

Products for advanced military and industrial applications in the molded and laminated plastics and vulcanized fibre lines. Contents include high temp plastics, a materials directory, applications and specifications charts. — *Continental-Diamond Fibre Co.*

Circle 217 on Inquiry Card for more data

Magnesium-Lithium

Booklet contains properties and applications of magnesium, titanium, litium and other alloys.—*Brooks and Perkins, Inc.*

Circle 218 on Inquiry Card for more data

Carbide Price List

A 48 page price list that includes reductions on many carbide items, and lists a line of blanks and tools, carbide and ceramic inserts, tool holders and face mill cutters.—*Vascoloy-Ramet Corp.*

Circle 219 on Inquiry Card for more data

Air Operated Valves

Bulletin 361 describes a light weight, air operator for on-off use with ⅛ to 9/16 in. tubing valves with either air-to-open or air-to-close designs.—*Autoclave Engineers, Inc.*

Circle 220 on Inquiry Card for more data

Technical Capability

Booklet outlines facilities for design, research and production of systems utilizing photography, optics, and infrared equipment. — *Eastman Kodak Co.*

Circle 221 on Inquiry Card for more data

To Build or Buy

Booklet offers a five point program for reaching a decision on whether a specific component or assembly should be built in a company's own plant or farmed out to a contract manufacturer.—*Pamco, Inc.*

Circle 222 on Inquiry Card for more data

Industrial Development

"Metropolitan Miami Memo" contains a cross section of newsworthy items about Miami's industrial and commercial growth. — *Miami-Dade County C of C.*

Circle 223 on Inquiry Card for more data

Silicones

Eight-page publication contains data and examples of silicones in use in a variety of electrical and electronic applications. — *G.E., Silicone Products Dept.*

Circle 224 on Inquiry Card for more data

Indicator Controllers

Four-page bulletin describes a new line of thermo electronic indicators and indicating controllers — instruments that provide automatic indication and/or control of a variety of industrial processes. — *Thermo Electric Co., Inc.*

Circle 225 on Inquiry Card for more data

Visitors Guide

Guide and facilities brochure describes plant layout and manufacturing services. Product descriptions include Aerial cameras, control systems, ground support equipment and missile guidance systems. — *Chicago Aerial Industries, Inc.*

Circle 226 on Inquiry Card for more data

LASER Effect

Booklet describes Light Amplification by Stimulated Emission of Radiation. Tells how it is produced and discusses flashtubes for its application.—*General Electric Co.*

Circle 227 on Inquiry Card for more data

Capability Brochure

Air data instruments and systems for commercial and military aircraft and missiles are discussed in an 8 page brochure, it defines a new company's concept of reliability standards —touching on quality control and customer service.—*Astek Inst. Corp.*

Circle 228 on Inquiry Card for more data

Management Guide

"Management Guide To Productivity" is the title of a booklet which lists seven measures for more profits through better materials handling. Included are blank forms for conducting your own materials handling survey.—*Yale & Towne Mfg. Co.*

Circle 229 on Inquiry Card for more data

Blueprint Files

Pamphlet describes an open type steel filing cabinet for filing engineering drawings, blueprints, maps and other large sheets. System utilizes a dowel arrangement on sliding tracks. —*Dancer Stikfile Co.*

Circle 230 on Inquiry Card for more data

Stainless Steels

Booklet on the newest types of stainless steels including precipitation hardenable stainless that are common in missile applications. — *Republic Steel Corp.*

Circle 231 on Inquiry Card for more data

continued on next page

AIRCRAFT DESIGN ENGINEERS - SENIOR

Inquire about new opportunities at

AIRLIFT CENTER U.S.A.

Requires engineering degree and five or more years experience in: Structural, avionics, controls, electrical and electronics, empennage, equipment, fuselage, hydraulic, landing gear, power plant or wing design.

ENGINEERING DRAWINGS CHECKERS — Structural Engineering degree and previous structural design experience preferred. Must have three or more years engineering drawings checking experience. Openings at intermediate and senior level.

AIRLIFT CENTER U.S.A. at Marietta is eight miles from the city limits of beautiful Atlanta. Due to its location on a plateau at a 1050 ft. altitude, residents of the Greater Atlanta-Marietta area enjoy a year-round climate unparalled in the East.

Combine work in an exciting professional environment with living in one of the finest cities in the country.

Write in confidence to: Hugh L. Gordon, Professional Employment Manager, Lockheed Aircraft Corporation, 839 West Peachtree Street, Atlanta 8, Georgia.

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MICROSCOPIC CLEANING of Precision Parts Economically Efficiently

In an AGE OF SPECIALISTS ... we at National SPECIALIZE in the application of ultrasonic energy for the cleaning of metals, plastics, glass, ceramics and other materials.

NATIONAL ULTRASONIC OFFERS:

- Broad knowledge and experience in the cleaning field.
- The most complete and versatile line of equipment.
- An applications laboratory that will analyze your problem and provide sound recommendations.

If you think your product or products might benefit by ultrasonic cleaning . . . write, wire or call today for a National Ultrasonic representative.

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Circle 15 on Inquiry Card

NEW LITERATURE

Worth Asking For

. . . continued

Technical Data

Brochure describes an acid type electroplating formulation that produces pure 24 karat gold deposits to any desired practical thickness. Adaptable for still and barrel plating.—*Sel-Rex Corp.*

Circle 232 on Inquiry Card for more data

Control System

Four page brochure on jet vane control system for directional control of missiles by hot gas actuation.—*Whittaker Controls Div. of Telecomputing Corp.*

Circle 233 on Inquiry Card for more data

Unit Mechanization

Described in a 12-page brochure is an approach to automation based upon unit mechanization of specific work functions, rather than the fully automatic production line concept.—*Jered Equipt. Co.*

Circle 234 on Inquiry Card for more data

Data Processing

Bulletin gives photos, specifications, applications, and listings of optional peripheral or accessory equipment for the Model 210 system.—*Beckman Systems Div.*

Circle 235 on Inquiry Card for more data

Steel Design

New concepts in steel design and engineering are covered by four papers printed in a 59-page brochure.—*U. S. Steel Corp.*

Circle 236 on Inquiry Card for more data

Diffusion Furnaces

Bulletin describes, in detail, gaseous and solid diffusion furnaces as an aid for basic research, pilot-plant studies and production of semi-conductors.—*Lindberg Engineering Co.*

Circle 237 on Inquiry Card for more data

Large Size Caps

Bulletin announces the availability of a line of larger size protective caps and sleeves, made of polyethylene, to safeguard threaded shafts, drill pipe and other components of large diameter or odd shape.—*Protective Closures Co., Inc.*

Circle 238 on Inquiry Card for more data

Tapered Tubing

Straight and reverse tapered tubing ranging in size from .080 to 1.500 in. o.d. is described in data memorandum sheet no. 29.—*Superior Tube*

Circle 239 on Inquiry Card for more data

Systems Integration

Booklet describes the "ins and outs" of systems integration—touching on cost cutting methods. Several case histories of systems produced under this plan are included.—*The Bendix Corp.*

Circle 240 on Inquiry Card for more data

Receptacles

Brochure describes a line of electrical terminations and receptacles for use in hermetically sealed compressors.—*AMP Incorporated*

Circle 241 on Inquiry Card for more data

India's Development

Economic development in the last ten years and a proposed five year plan for growth, industry-wise, is discussed in a 20 page brochure. — *Information Service of India*

Circle 242 on Inquiry Card for more data

Decimal Chart

Desktop or wall chart measures 11 x 14 in. Color coded design makes fractions and wire gauge conversions quickly.—*Ohio Seamless Tube*

Circle 243 on Inquiry Card for more data

Protective Papers

A line of pressure sensitive papers for use in protecting metal, glass or plastic surfaces. Brochure gives information on a variety of adhesive backings and thicknesses. — *Mask-Off*

Circle 244 on Inquiry Card for more data

Lithium Chemicals

Technical data bulletin describes commercial and experimental lithium chemicals for air-conditioning, catalysis, electronics, metallurgy, ceramics and other fields.—*Foote Mineral Co.*

Circle 245 on Inquiry Card for more data

Numerical Control

Booklet defines the meaning of numerical control and explains the use of punched tape in machine tool applications. — *Friden, Inc.*

Circle 246 on Inquiry Card for more data

Capability Brochure

Engineering, production, manufacturing, assembly and quality control facilities in the field of pneumatic and hydraulic valves is presented in a 24-page brochure.—*Marotta Valve*

Circle 247 on Inquiry Card for more data

Computer Simulator

Technical bulletin describes an automatic digital computer simulator that tests and evaluates complete memory systems.—*Rese Engineering*

Circle 248 on Inquiry Card for more data

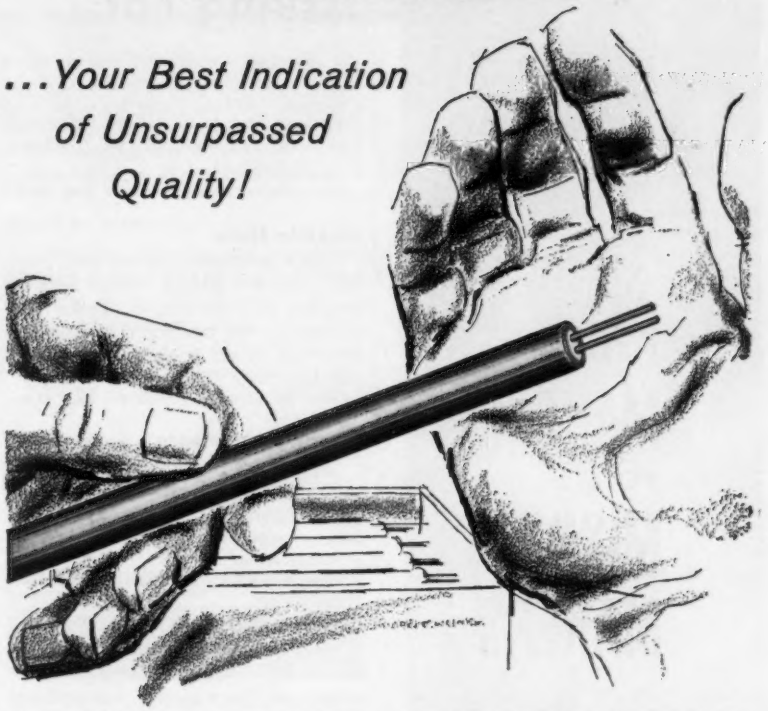
Anechoic Chambers

Brochure discusses a line of broadband and resonant microwave absorber materials for use in anechoic

continued on next page

Ceramo® Performance—

...Your Best Indication of Unsurpassed Quality!



"Ceramo" Performance in your most severe temperature measuring applications is your best indication of "Ceramo" Superiority! This metal sheathed, ceramic insulated thermocouple wire—used for all types of thermocouples—assures rapid response and consistent accuracy—long life with stability!

Developed by Thermo Electric Co., Inc. more than ten years ago, "Ceramo" has mastered the most difficult temperature measuring jobs; jet engines, nuclear reactors, exotic missile and rocket fuel tests, and many others, equally severe. It can be formed to practically any configuration without insulation loss and withstands extremely high pressures in measuring temperatures from minus 450°F. to plus 4000°F., and over!

Careful Manufacture

"Ceramo" is closely supervised throughout production, to assure accuracy and uniformity. In our own wire mill—the wire elements are drawn, carefully calibrated and rigidly tested for spurious emf. generation. Various inert metallic oxide insulating materials are specially processed for purity. Sheath materials are scrupulously inspected for continuity and sheath integrity. The finished "Ceramo" wires are heat-treated and annealed for proper ductility and stabilization.

Rigid Quality Controls

Quality Controls and Inspection for "Ceramo" production exceed the requirements of MIL-Q-9858, 4/9/59, "Quality Control System Requirements".

Many Types Available

"Ceramo" thermocouple wires are available in single, duplex, four and six conductor types, of standard thermocouple elements, including various Platinum-Rhodium combinations, and special Iridium-Rhodium and Tungsten-Rhenium calibrations. Wire gage sizes range from 36 to 12; outside diameters from 1/25″ to 7/16″. Sheath materials are available in Stainless Steels, Inconel, Aluminum, Platinum or Copper. Lengths to 30 feet are stocked—lengths to 60 feet can be supplied.

When You Must Be Sure—Specify "Ceramo" by Thermo Electric!

Write today for "Ceramo" Bulletin 31-1

Thermo Electric

THERMO ELECTRIC Co., Inc., Saddle Brook, New Jersey

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

20 YEARS • *Temperature Measuring Systems and Components*

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As the initial flight test of the Minuteman revealed the success of America's first solid propellant ICBM, we at Fenn took an extra measure of pride in our precision parts in the vector nozzles.* It added missile components to a long list of other precision Fenn-made parts that fly. If you need a reliable source . . . with long experience . . . completely modern facilities and thinking, we would like to tell you more about Fenn. Copies of our Facilities Folder and Facts About Fenn are yours for the asking. The Fenn Manufacturing Company, Fenn Road, Newington, Connecticut.
*Vector nozzles designed by Arde-Portland for the Thiokol first stage rocket engine.
FENN
Circle 17 on Inquiry Card

NEW LITERATURE

Worth Asking For

. . . continued

chambers and to eliminate reflections inside of radomes.—*B. F. Goodrich, Sponge Products Div.*

Circle 249 on Inquiry Card for more data

Flexible Hose

High pressure aircraft and extra high pressure missile flexible hose assemblies of Fluoroflex-T (Teflon) for pneumatic and hydraulic systems are described in an 8 page catalog—*Resistoflex Corp.*

Circle 250 on Inquiry Card for more data

Visual Instruments

Brochure features equipment showing weights on direct reading dials. Equipment is for use where printed weights are not required.—*Streeter-Amet Co.*

Circle 251 on Inquiry Card for more data

Power Filters

Booklet describes five filters designed to suppress harmonics generated in high-power transmitters ranging from 400 to 6,000 megacycles. In addition, it shows how use of the filters can increase fundamental power-handling capacity by absorbing unwanted harmonic signals. —*General Electric Co.*

Circle 252 on Inquiry Card for more data

Bushings

Pamphlet (No. 60A) is illustrated with line drawings showing how superior cylindrical fits are obtained in bolting structural joints, clevis and hinge pins, rod end bearing pins, bearing and seal applications, etc.—*Adjustable Bushing Co.*

Circle 253 on Inquiry Card for more data

Thermoelectricity

"The Coming Age of Thermoelectricity" bulletin points out the present state of this science. Specifications are given on a compact power package that creates electricity directly from heat.—*Harco Laboratories, Inc.*

Circle 254 on Inquiry Card for more data

Rectifier Handbook

A 185-page Silicon Zener Diode and Rectifier Handbook, covering basic theory, design characteristics and applications for zener diodes and rectifiers.—*Motorola Semiconductor Products Inc.*

Circle 255 on Inquiry Card for more data

SAFETY *by* HAWS

HAWS SAFETY FOUNTAINS

Wash harmful fuels and chemicals from eyes and facial areas, instantly! Prevent discomfort and serious injury. Units may be wall or pedestal mounted; with hand or foot operated quick-opening valves.

7900 Series—Maximum coverage eye/face-wash. 6 spray outlets in extra large stainless steel bowl set up soft, drenching mist for positive first aid. Large hand valve.

7100 Series—Eye-wash sends pressure-controlled streams from chrome plated brass heads. Acid-resisting enameled iron bowl.

7700 Series—Eye/face-wash simultaneously sprays water from perforated copper ring and fountain heads. Stainless steel bowl.

HAWS SAFETY SHOWERS

Instantly flood the body with torrents of rushing water to wash away injurious contaminants. Your choice of single head or multiple nozzle showers; available with hand or foot valves.

Model 8590—Multiple Nozzle Shower instantly drenches victim from all angles. Large hand valve.

WRITE FOR HAWS DETAILED SAFETY CATALOG TODAY!

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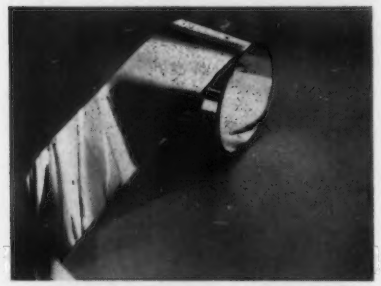
San Francisco 11, California, U.S.A
Circle 18 on Inquiry Card

NEW Materials

Buffed Strip

Stainless steel strip with a highly reflective finish called Unibrite is available from a production line buff-



ing operation at the producing mill. Coils up to 26.5 in. wide, weighing 18,000 lb can be buffed on both sides with the process.—*Universal-Cyclops Steel Corp.*

Circle 256 on Inquiry Card for more data

Ruby Rods

Foot long, 90-deg oriented ruby rods for optical maser applications. Ruby boules are chrome doped and slow grown (growing cycle 42 hr, annealing 120 hr). It is claimed that the boules will yield cylinders with 0.5 in. diam x 8 in. or ⅜ in. diam x 12 in.—*Adolf Meller Co.*

Circle 257 on Inquiry Card for more data

Encapsulation Technique

Technique is said to result in an increase in the power dissipation of high frequency MADT transistors from two to four times. Higher power dissipation could broaden application of MADT's to include low and high dissipation switching circuits and higher power communications applications.—*Philco Corp.*

Circle 258 on Inquiry Card for more data

Metal Coating

Sacrificial metal coating, called Tyzin, is said to offer excellent resistance, with or without a topcoat, to organic or inorganic solvents, salt water, oils or greases. Tyzin consists of a modified lacquer base blended with metal zinc powder. Coating requires no curing agent.—*U. S. Stoneware*

Circle 259 on Inquiry Card for more data

Resin Lock

Liquid resin, called Loctite, is an anaerobic polymer. The maker claims that the resin, when allowed to penetrate small clearances between assembled metal parts, will self-harden into a tough bond, making assembly impervious to vibration loosening.—*American Sealants Co.*

Circle 260 on Inquiry Card for more data

Flexible Adhesive

General purpose adhesive for bonding natural and synthetic rubber, plastics, or fabrics to itself or to glass, steel, aluminum and other surfaces. It is said to be permanently flexible.—*Chemical Development Corp.*

Circle 261 on Inquiry Card for more data

Lubricating Layer

Technique chemically converts a milliinch depth of part surface to a multi-metal alloy with lubricating properties. Microscopic structure con-

sists of a resilient lattice-work of fibre-like crystals interlaced with the crystalline structure of the parent model. Known as "Hi-T Lube" for the —100 to 1000°F range, "Mach II" for up 1500°F and "Mach III" for higher temp.—*General Magnaplate Corp.*

Circle 262 on Inquiry Card for more data

Missile Plastics

Plastics under development are intended for advanced rocket motors and will be designed to withstand 10,000°F temp. Compounds of polymeric and composite (ceramic and refrac-

tory plus plastic) are expected to resist sonic and supersonic rocket exhaust velocities for several minutes. —*Hughes Aircraft Co.*

Circle 263 on Inquiry Card for more data

Hi Temp Materials

Tetraboron silicide and hexaboron silicide are being synthesized in large quantities. It is claimed that material

can be heated to 2000°F and then plunged into cold water without shattering. Samples shown were machined before final heating.—*Allis-Chalmers Mfg. Co.*

Circle 264 on Inquiry Card for more data

Insulating Cement

Dry ceramic powder is mixed with a supplied liquid to form a homogenous paste which dries and cures at room temp. Firm claims cured cement has melting point above 5000°F. Insulator weighs 2 g/cc and the hardened cement can be machined.—*Semicon of Calif., Inc.*

Circle 265 on Inquiry Card for more data

Glass-Resin Laminate

Glass-cloth, melamine-resin laminate is said to have excellent moisture resistance, flexural strength, impact, flame retardance and dielectric strength. Called Textolite 11588, the material is available in thicknesses from .015 to 3.5 in.—*General Electric Co.*

Circle 266 on Inquiry Card for more data

Superconductor

Cold-worked alloy of niobium and zirconium offers no resistance to electrical current. A wire which can be easily coiled was drawn from the superconductor and it is claimed that at liquid helium temp the wire conducted 100,000 amp electrical current per square centimeter in a moderately high magnetic field (30,000 gauss). Developers expect it to retain same characteristics in higher magnetic fields. — *Atomics International, div. NAA*

Circle 267 on Inquiry Card for more data

continued on next page

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PROJECT

RCA Titan Project, Marysville, California, has a limited number of openings for experienced Missile Engineers willing to step *up* to RCA. Openings exist at all levels in these engineering areas:

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NEW Materials
continued

Flame-Resistant Coating

Flame and heat resistant coating is claimed to withstand temp in excess of 4000°F. Known as PyroShield

21, the material, when exposed to heat or flames, swells and forms a protective barrier. — *Columbia Technical Corp.*

Circle 268 on Inquiry Card for more data

Plastic Conductor

Plastic material is said to have good conductive properties and pilot uses of the material seem to indicate that it is well adapted to the production of printed circuits where a flush surface is desired. Other applications include waveguide, RF connectors and electronic components.—*Mesa Plastics Co.*

Circle 269 on Inquiry Card for more data

Aluminum Filled Epoxies

It is said that aluminum filled epoxies offer tooling and adhesive compounds with better than average strength up to 400°F. With curing agents they will set with heat or at room temp with low shrinkage. — *Furane Plastics Inc.*

Circle 270 on Inquiry Card for more data

Dry Film Lubricant

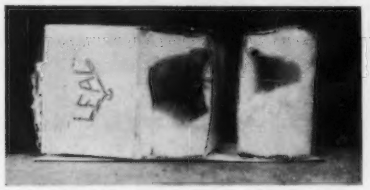
Inorganic-bonded, dry film lubricant has a temp range from —300 to 1200°F. Called Molykote X-15, it is said to be insensitive to liquid oxygen, unaffected by 5 x 10^6 roentgen gamma radiation, and retains lubricating properties under high vacuum. Ma-

terial can be brushed or sprayed and air dries at room temp. — *Alpha-Molykote Corp.*

Circle 280 on Inquiry Card for more data

Foam Packing

Foam in place packaging system utilizes urethane foams. System in-



cludes automatic metering and dispensing equipment for foams.—*Leal Corp.*

Circle 281 on Inquiry Card for more data

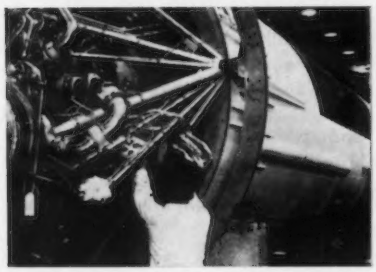
Glass Fabric

Fiber glass lining, said to be more impact-resistant than an equivalent weight of stainless steel, is based on a weave pattern that eliminates interlacing of the structural yarns in the fabric and leaves them free to assume greater impact loads. The laminate was developed for cargo and baggage compartments of aircraft. — *J. P. Stevens & Co.*

Circle 282 on Inquiry Card for more data

Heat Reflector

Pressure-sensitive tape, designed to reflect extreme heat, is claimed to be capable of withstanding temp to



600°F continuously, and 3000°F for short periods. Tape is being applied to parts of the Titan missile in photo. —*Minnesota Mining & Mfg. Co.*

Circle 283 on Inquiry Card for more data

Transparent Resin

General purpose resin was developed for extrusion wire coating and is said to have excellent stability and weatherability. Called Zytel 53, it is transparent and suggested for appli-

continued on next page

SIMPLY INTERCHANGE TIPS FOR

3 SOLDERING TEMPERATURES

Magnastat tips are available in 3 different temperature ranges: 750°F., 700°F. and 600°F. controlled to ±3% approximate variance. Merely interchange the tip for the soldering temperature best suited for the job. Over 40 standard tip styles available in 3 temperature ranges.

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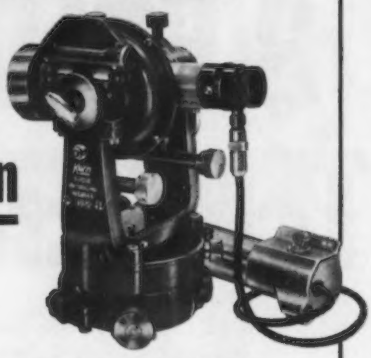

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Circle 21 on Inquiry Card

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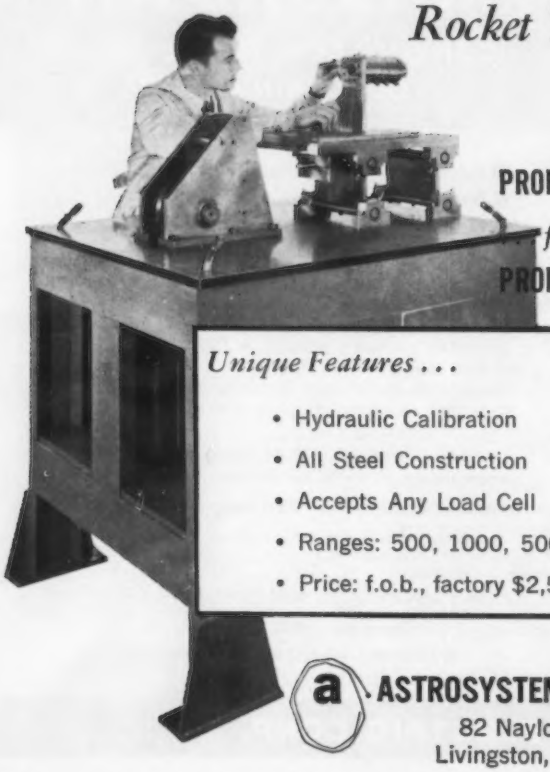

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Circle 22 on Inquiry Card

NEW Materials

continued

cations where resistance to occasional sunlight is required.—*E. I. du Pont de Nemours & Co.*

Circle 284 on Inquiry Card for more data

RTV Silicone Rubber

Six grades, RTV-11, 20, 40, 60, 88, 90, of liquid silicone rubber compounds are being offered in single-lb quan-

tities. Package comes with one lb jar of RTV, catalyst and accessories for measuring catalyst and stirring. — Silicone Products Dept. *General Electric Co.*

Circle 285 on Inquiry Card for more data

Anti-Rust Liquid

Light oily liquid for protection of ferrous metal products during storage or shipping. A thin film of Ferro-Gard on metal surfaces gives off an invisible vapor that envelops the metal. Liquid can be applied by brush, spray, dip or fogging and can be wiped off with a cloth when product is ready for use.—*Ronco Laboratories*

Circle 286 on Inquiry Card for more data

Nylon-Base Plastic

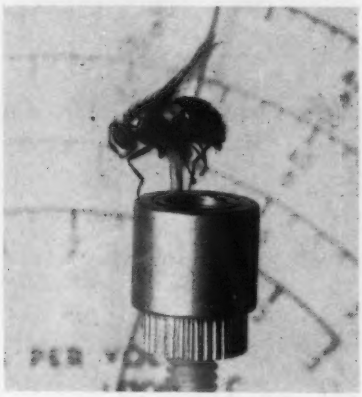
Nylon-based reinforced plastic for missile use is light weight. Features claimed include: low thermal conductivity, temp range over 4000° F, and high deflection under load. Called Tayloron PN, the material is made from nylon fabric impregnated with a phenolic resin. Material is available in sheets, rods, plate, tubes, molded shapes and molding forms.—*Taylor Fibre Co.*

Circle 287 on Inquiry Card for more data

NEW Electronic Products

Variable Transducer

The mount of this piezoelectric transducer is said to eliminate 85 per cent of the noise produced by more



conventional units. Sensitivity of the transducer is shown here by its reaction to a housefly's wing flutter. Device can be used to measure shock velocity, blast pressure, compression and expansion wave durations—applications include wind tunnel testing and rocket and missile usage.—*Mirax Chemical Products Corp.*

Circle 288 on Inquiry Card for more data

Constant 1.5 V-DC Supply

Compact unit supplies 1.5 ±.0037 VDC at rated load of 1.4 MA at 20°C. Device is 2.9 x 2.7 x 2.3 ins. and weighs 14 ounces. Replacing of standardization circuitry in potentiometer or wheatstone bridge instruments is normal application.—*Thermo Electric Co., Inc.*

Circle 290 on Inquiry Card for more data

1000 LPM Printer

Data processing printer is said to be capable of printing up to 1000 lines per minute in either 120 or 160 character lines. Single sheets or multiple carbon forms, from four inches to 19 inches in width can be handled by this unit. Printer is designed to operate with the 301 data processing system.—*Radio Corp. of America.*

Circle 291 on Inquiry Card for more data

Temperature Chamber

System is said to comply with most of temperature-humidity test specifications of government and industry in electronics, missile and aerospace applications. Standard unit is capable of producing relative humidities from 20 to 95 per cent at dry bulb temps from 35 to 200°F. Chambers are available in 8, 27, and 64 cubic foot sizes.—*Wyle Laboratories*

Circle 292 on Inquiry Card for more data

Desk-Size Computer

Features of this new computer are a magnetic core memory of 8192 words expandable in modules to 32,768 words; buffered input and output which is independent of the main computer program and a manual stop with program interrupt. The speed of Model 160A is said to be, "60,000 instructions per second."—*Control Data Corp.*

Circle 293 on Inquiry Card for more data

Frequency Meter

Resolution waveguide frequency meter for use in the 7.5 to 9.6 Gc range offers continuous resolution over the entire range with 1mc as the

least dial division. Unit is said to maintain accuracy of ± 1mc over a temperature range of from +32° to +85°F.—*FXR, Inc.*

Circle 289 on Inquiry Card for more data

Vector Analyzer

Unit can be used to measure phase error between unknown and standard components with deviation that is as small as .005°—also for measuring voltage across two points which are both above ground potential. Specifications of Type 202 are: Phase angle range—0-1, 0-2, 0-4, 0-10, 0-20, and 0-180 degrees. A panel switch is provided for inserting 180-degree phase shift to step up the above ranges to 360 degrees. — *AD-YU Electronics Lab., Inc.*

Circle 295 on Inquiry Card for more data

Radiation Monitor

New monitor gives both audible and visual warning signals whenever the wearer is exposed to radiation from reactors, radioisotopes, particle accelerators, large X-ray machines, etc. Fountain-pen styled detector gives off high pitched chirps and flashes a neon light when a change in radiation level occurs. Unit is powered by a miniature mercury cell that is said to give about 30 days operation. — *The Victoreen Instrument Co.*

Circle 296 on Inquiry Card for more data

Rocket Test Stand

Test stand, for the measurement of rocket thrust, employs damped flexure plates for 0-500 lbf, parallelogram roller bearing system for 500-5000 lbf and a rolling table system for 5000-25,000 lbf. The table on which the engine is mounted is constructed of light metal with "T" slots milled into the surface so that the connection points for securing the engine are moveable over the full surface of the table.—*Astrosystems, Inc.*

Circle 297 on Inquiry Card for more data

Event Recorder

Inkless event recording unit is said to operate for more than 50 days without a change in charts. Unit uses electrically heated stainless steel styluses to write 10 or 20 channels of "yes-no" or "on-off" information on special non-wax paper. Recorder is applicable to conveyor operations, time studies and various chemical processes.—*Esterline Angus Instrument Co., Inc.*

Ratio Analyzer

Output to input Analyzer designed for use in checking calibration of accelerometers, rate-gyros and other

NEW Electronic Products

Continued

devices having a potentiometer pick-off. Unit has two operating ranges—1K to 10K and 5K upwards, switch in rear of cabinet indicates range setting. Analyzer consists of a high-precision linear potentiometer and a voltage supply along with the dual range meter. When connected to an external potentiometer being tested, the two pots form a Wheatstone bridge with the meter to indicate bridge balance.—*Humphrey, Inc.*

Circle 75 on Inquiry Card for more data

Oscillator

Inductance controlled oscillator designed for use in all types of variable inductor transducers is said to meet or exceed all applicable MIL specs. Designated model LSE, the unit is completely transistorized and requires only two wires from the transducer. This eliminates the need for a tap on the coil. Manufacturer claims the unit can withstand 100 g acceleration and vibration with less than 1% bandwidth change.—*Pace Engineering Co.*

Circle 76 on Inquiry Card for more data

Neutron Dosimeter

Silicon disc mounted between two electrical contact pins records fast neutron dosage cumulatively and is

insensitive to all other forms of radiation. Fast neutrons passing through the dosimeter knock some of the silicon atoms from their normal positions, permanently changing the electrical properties of the silicon. This change is measured in "tissue-rads"—units of radiation damage to human tissue.—*Battelle Memorial Institute.*

Circle 294 on Inquiry Card for more data

Synchronous Motor

Unit design insures that the rotor of the synchronous motor will always synchronize at the same relative position with respect to the rotor stating field. Rotor is said to orient within ± 5 deg—no DC excitation of the rotor is required. Motor is 2-phase, 60 cycles, 115v ac with a housing that measures 1¾ inches in dia. and 2 inches in length. — *Kollsman Motor Corp.*

Circle 77 on Inquiry Card for more data

Personal Communications

VHF-FM communications unit has a transistorized receiver that incorporates a crystal-filter selectivity package, electronic squelch control and audio outputs for loudspeaker and earphone. Transmitter and receiver units are packaged separately — receiver can be carried in a shirt pocket and the transmitter on a shoulder strap. — The Bendix Corp. — *Bendix Radio Div.*

Circle 78 on Inquiry Card for more data

Relief Valves

An adjustable, positive seating relief valve for liquid or gas service to 5000 psi combines a resilient, flat seated nylon disc with guided lift design. The valve is said to maintain a tight leakproof seal until the preset pressure is exceeded. The nylon disc compensates for any surface irregularities on the valve seat thereby insuring more positive sealing.—*Combination Pump Valve Co.*

Circle 79 on Inquiry Card for more data

Tape Comparator

For verification and duplication of tapes and edge cards having 5 to 8 bit codes. System includes two motorized tape readers connected for verification of tape recently duplicated. In numerical control application a tape duplicated from one that has been in use for some time is compared with the original. The tapes are read simultaneously, if an error is detected in the new tape the unit stops and indicates the position of the error.—*Friden Inc.*

Circle 80 on Inquiry Card for more data

Balancer

Portable unit, for in-place analysis and correction of unbalance conditions, weighs 32 pounds. The machine is said to be able to isolate the frequency of any unbalance part rotating between 225 and 3600 rpm. Unit is equipped with astorboscopic light, a standard pickup and shielded cable. Operates from 110V source.—*Tinius Olsen Testing Machine Co.*

Circle 81 on Inquiry Card for more data

Degreaser

Ultrasonic degreaser designed to operate with Freon solvent. Freon is recommended for use in cleaning parts containing any plastics, metals or elastomers that would be attacked

by chlorinated solvents. Parts are placed in an ultrasonic chamber to loosen contaminants and then transferred to a vapor area where they receive a final cleansing with distilled Freon vapors. — *National Ultrasonic Corp.*

Circle 298 on Inquiry Card for more data

Circuit Tester

A random access, card programed automatic tester called FACT-RC for use in checking wiring harnesses and electrical assemblies for current continuity and high potential. Tests are controlled by programmed IBM cards corresponding to a unit's individual test requirements. One card is required for each circuit, and the machine processes 72 cards a minute. Circuit faults are noted by type and location on a print-cut tape, and by the cards as they fall into "condition of circuit" bins.—*Hughes Aircraft Co.*

Circle 82 on Inquiry Card for more data

Overvoltage Protection

A new line of laboratory power supplies features electronic cutoff in 50 microsecond, for internal or external malfunctions. The unit is said to fully protect sensitive loads such as transistors, diodes, etc., from overvoltages down to 0.5 volt above set point.—*Systems Research Corp.*

Circle 83 on Inquiry Card for more data

Servo Drive

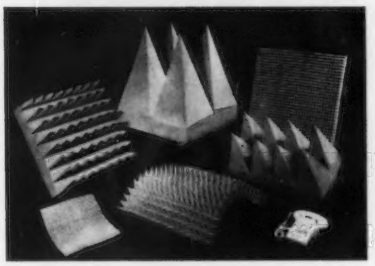
New step servo drive for potentiometers is designed to operate with step servo controllers and pulse sources. Unit consists of an in-line mounted step servo motor and gearhead, which permits integral mounting of the potentiometer. This feature allows several pots to be positioned simultaneously from a single controller.—*Automation Development Corp.*

Circle 84 on Inquiry Card for more data

NEW Parts and Components

Microwave Absorber

Line of microwave absorbers is claimed to substantially improve the performance of anechoic chambers. Chambers with reduced cross-section



are yielded by the material's claimed excellent wide-angle absorption. — *B. F. Goodrich*

Circle 50 on Inquiry Card for more data

Metal Seal

Cryogenic metal seal is said to provide leakproof sealing through high and low extremes of pressure and require low bolt and flange loads. Standard cryogenic seals in aluminum with Teflon covered sealing points are available in sizes from one to 20 in.— *Rocketdyne*

Circle 51 on Inquiry Card for more data

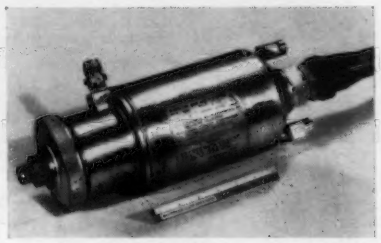
Mixing Attachments

Modular mixing attachments for 300KW arc plasma generator are used to create environments for re-entry testing of materials, heat transfer and gas dynamic evaluations of high temp gases and plasma jet thrust studies. AM-4 model is designed to operate into ambient pressures between 0.5 and 2.0 atmospheres and provide a subsonic plasma stream. AM-5 unit produces Mach 2.5 plasma stream.—*Plasmadyne Corp.*

Circle 52 on Inquiry Card for more data

Gas Generator

Cool gas generator for inflating light-weight rubber/fabric bags incorporates an electrical initiator, a solid propellant for gas generation



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Douglas needed a superalloy bellows assembly for the auxiliary power unit exhaust system on the U. S. Army's Nike Zeus. Assembly had to withstand violent movements in operation under critical temperatures. Avica samples met all test requirements. When Douglas was required to meet an urgently accelerated missile shot at White Sands, N. M., within a week, they immediately turned to Avica. Modifications were required and close on-the-spot coordination of design specifications resulted in a successful modification program. Avica made 16 units and shipped order complete in 4 days. Douglas received parts 6 days from time of order, flew them to White Sands in time for scheduled shot.

Douglas Aircraft Company is part of the Army Ordnance-industry team developing the Nike Zeus Anti-missile System. Western Electric Company is the industrial prime contractor.

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NEW Parts and Components

continued

and pressurization, and a coolant for temp control. Generator has potential for pneumatic systems such as satellite and spaceship reaction systems.— *McCormick Selph Associates*

Circle 53 on Inquiry Card for more data

Command Receiver

Transistorized command destruct receiver is designed for range safety and control in missiles and drones. The CR-10 has four isolated control channels, provision for external units to accommodate up to 20 IRIG channels, and isolated telemetry output. Volume of package is 38 cu/in. and weight is 2.5 lb. — *Ramo-Wooldridge Div., TRW*

Circle 54 on Inquiry Card for more data

Venturi Valve

Valve can be used for liquid or gas service. Valve consists of a pilot operated shutoff valve seating at the throat of a contoured venturi section. A small electrical solenoid or toggle type manual valve is said to be sufficient to pilot valves at extremely high pressures.—*Fox Development Co.*

Circle 55 on Inquiry Card for more data

Hot Air Valve

Thermostatic-type hot air valve is designed to prevent nacelle icing on turbo-fan jet powered aircraft. In production for use on Boeing 707, the

unit, known as CECO Model HAV-10, can be modified for other aircraft. Unit mounts on the engine and thermostatically controls flow of hot engine bleed air to the leading edge of the powerplant nacelle. — *Chandler Evans Corp.*

Circle 56 on Inquiry Card for more data

Fiber Glass Reflector

Close-tolerance fiber glass antenna reflectors could be used to measure radiation from other planets. Reflectors are said to hold their shape under

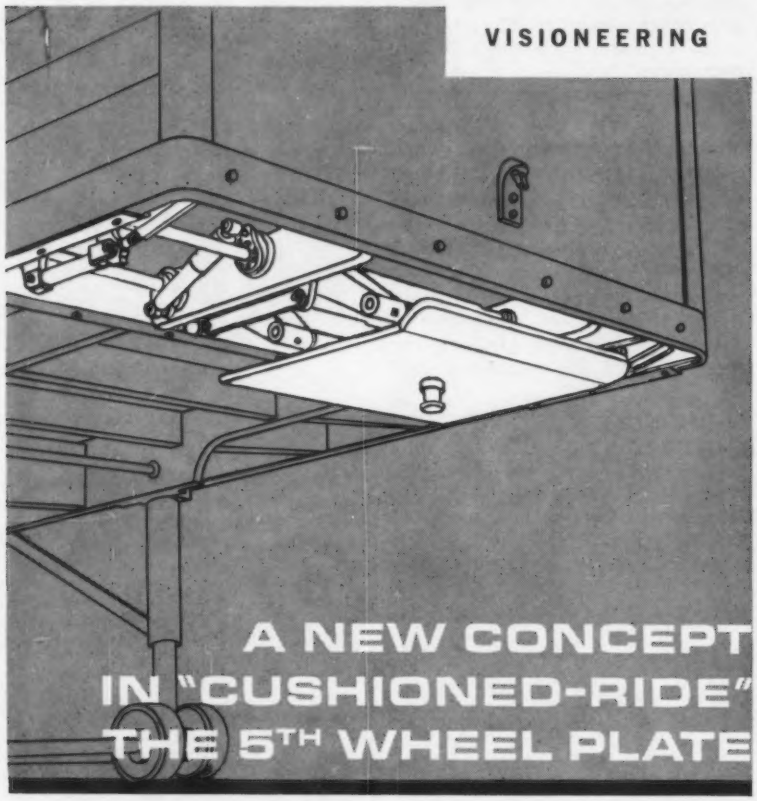
heavy wind forces and temp extremes and give stronger focus to radio waves. It is claimed that a surface tolerance of .005 in. can be held. — *The Boeing Co.*

Circle 57 on Inquiry Card for more data

Solid Motor

Solid propellant rocket motor, called Kisha, designed for sounding vehicles, sled and missile propulsion, utilizes a hot-particle, shockless type igniter with electric initiation. Alloy steel case is 72 in. long with a 6.5 in. diam. It is available in a variety of burning times and thrust levels. — *Rocket Power Inc.*

Circle 58 on Inquiry Card for more data



■ Unlike our other heavy-duty, soft-ride suspension systems, the 5th Wheel Plate utilizes torsion bars instead of springs. This unit was designed and patented primarily for trailers hauled by tractors and provides the maximum shock resistance for the most fragile of cargoes, regardless of road or terrain.

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Circle 27 on Inquiry Card

X-Band Limiter

X-band all solid state microwave power limiter is said to be satisfactory for use in radar systems as a mixer crystal protector. Advantages claimed for the device include completely passive operation, instantaneous recovery time and long life. — *Hughes Aircraft Co.*

Circle 59 on Inquiry Card for more data

Range Simulator

Antenna-range simulator designed for flight-line testing X-band aircraft radar at close range. Model 100 simulator is said to simulate fixed or moving targets and be usable within a few feet of the antenna to be tested. —*Melpar, Inc.*

Circle 60 on Inquiry Card for more data

Antenna Pedestal

Lightweight azimuth antenna pedestal is designed so that a mast of up

to 5.5 in. diam can be installed through the vertical axis. 32 in. diam table and bearing carriage are of cast aluminum. Pedestal is said to develop a torque of 1000 ft/lbs at 1.5 rpm.—*Antlab Inc.*

Circle 61 on Inquiry Card for more data

Vibration Mount

Center-of-gravity type mount consists of two sub-assemblies which incorporate stainless wire resilient elements within a lightweight aluminum mounting structure. Complete mounting assembly weighs 8.5 lb.—*Robinson Vibrashock Div.*

Circle 62 on Inquiry Card for more data

Sonar Pinger

Designed to measure the distance off-bottom of a coring tool, a camera or other oceanographic equipment, the sonar pinger is said to be accurate within 3 ft at depths of more than 4 mi. Self-contained unit has its own batteries, electronic power and control units in water-tight steel cases.—*Edgerton, Germeshausen & Grier, Inc.*

Circle 63 on Inquiry Card for more data

KIDDE PRESSURE VESSELS:

MORE SHAPES, MORE SIZES, MORE EXPERIENCE!

For more than 40 years, Kidde engineers have designed and made thousands of pressure vessels in a multitude of shapes, materials, capacities and strengths. Today, with pressure vessels an important part of missile or rocket programs, it's only logical that engineers rely on Kidde experience.

Kidde pressure vessels range from doorknob size to 3500 cubic inches capacity; from a life of 10 cycles to 500,000 cycles; pressures up to 20,000 psi. Kidde pressure vessels are made in steel, fiberglass, aluminum —welded or drawn—wire wound—minimum weight for application. Configurations are practically limitless—including cylindrical, spherical, conical, torus. Many are available on an off-the-shelf basis!

In addition to solving current problems in pressure vessel applications, Kidde engineers are also hard at work advancing today's techniques to solve tomorrow's problems. So, if pressure vessels have you stumped, why not call on Kidde for the answer . . . most people do!

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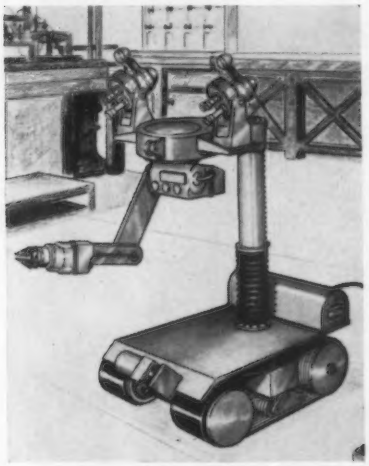
Walter Kidde-Pacific, Van Nuys, California • Walter Kidde & Company of Canada Ltd., Montreal, Toronto, Vancouver

Circle 28 on Inquiry Card

NEW Production Equipment

Vehicular Arm

New mobile remote handling system for performance of handling operations in many hazardous environments. Basic system is comprised of a vehicle with telescoping mast, a mechanical arm and an associated



cable-linked control system. Optional equipment includes a hoist/winch, dual television cameras and microphone or intercom setup. Minimum speed is 8 fpm—maximum 100 fpm, retracted height 45 in. width 24 in.—*General Mills, Inc.*

Circle 64 on Inquiry Card for more data

Vacuum Chamber

A welding chamber with built in rubber gloves for working with refractory metals features a loading and storage compartment adjoining the welding chamber. Molybdenum and Fansteel 82 have been fusion-welded in the chamber using a manual heli-arc welder with a thoriated tungsten electrode. Refractory metals ranging from .020 to ⅜ in. thicknesses have been welded successfully. —*Ling-Temco Electronics, Inc.*

Circle 65 on Inquiry Card for more data

Spectroscopy

Atomic absorption spectroscope consists of a hollow cathode discharge tube, several burners, a multiple pass attachment all mounted on an optical bar affixed to a high resolution grating spectrometer. A photomultiplier mounted on the exit slit of the spectrometer amplifies the light from the spectral line being studied. This signal is further amplified and recorded by a sensitive recording system.—*Jarrell-Ash Co.*

Circle 66 on Inquiry Card for more data

Vertical Contouring

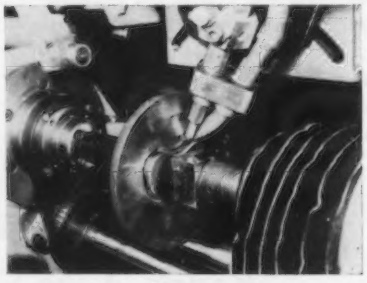
New vertical turning machine that can handle work pieces up to 30 in. in dia is said to work with an accuracy of ±150 millionths of an inch. The unit is equipped with a dual axis electro-hydraulic tracer system and an all-transistorized electronic control to guide both vertical and horizontal travel through 360 degrees of

motion. A 30 in. work table is powered through direct current drive and a four speed transmission, giving variable potentiometer controlled speeds from 12 to 1,000 rpm. Unit is shown here turning a missile nose cone.—*Frauenthal Div., Kaydon Engineering Corp.*

Circle 67 on Inquiry Card for more data

Cam Controlled Welding

Welding machine that will weld any two dimensional irregular contour including contours with straight or concave sections. For different type parts, cams can be designed in a



matter of hours. The cam design procedure is simplified to a formula and form chart and calculations can be made by simple arithmetic. Picture shows machine welding of an irregular contour part to a plate.—*Expert Welding Machine Co.*

Circle 68 on Inquiry Card for more data

Honeycomb Brazing

New method for brazing and soldering honeycomb sections with non-corrosive flux. Method is said to eliminate the need for atmospheres, vacuum, long heating and cooling cycles while joining ferrous or non-ferrous metals. These metals can be joined using a variety of brazing alloys or solders using optional heating methods and equipment.—*Murray Hill Research.*

Circle 69 on Inquiry Card for more data

Filtration Kit

Kit consists of a 10 cc glass syringe, with a special adapter and 25 membrane filters that remove particles down to .25 microns. A 23 gauge ½ in. needle is provided for

lubrication applications but the majority of use should come from the fluid analysis field where fine filtration is required. Kit is packaged in a wooden instrument case lined with sponge-like material. — *Bearing Inspection, Inc.*

Circle 70 on Inquiry Card for more data

Serrating Tool

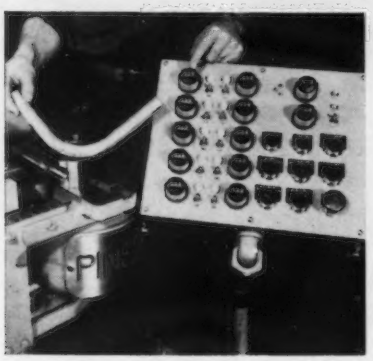
Designed to aid in installation of tubes in heat exchanger and condenser tube sheets this new tool cuts serrations or grooves in the tube sheet holes to assure tighter, leak proof joints when rolling or expanding tubes into tube sheets. Tool can be driven by a pneumatic or electric motor and is available with three

drives including morse taper, square or three jawed chuck.—*Airetool Mfg. Co.*

Circle 71 on Inquiry Card for more data

Programmed Bending

"Dial-A-Bend" is a new electronic angle of bend selector that programs



bend angles from blueprint specs or previous setups.—*Pines Engineering Co., Inc.*

Circle 72 on Inquiry Card for more data

Ultrasonic Measurements

Ultrasonic resonance gaging permits non-destructive thickness measurements when access to only one side is possible. Unit is shown here measuring seamless aluminum tubing used in the Titan missile. Measurements from .005 to 2.7 in. with an accuracy of .1 per cent are claimed by the manufacturer. — *Branson Instruments, Inc.*

Circle 73 on Inquiry Card for more data

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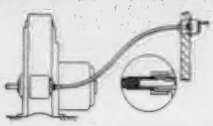

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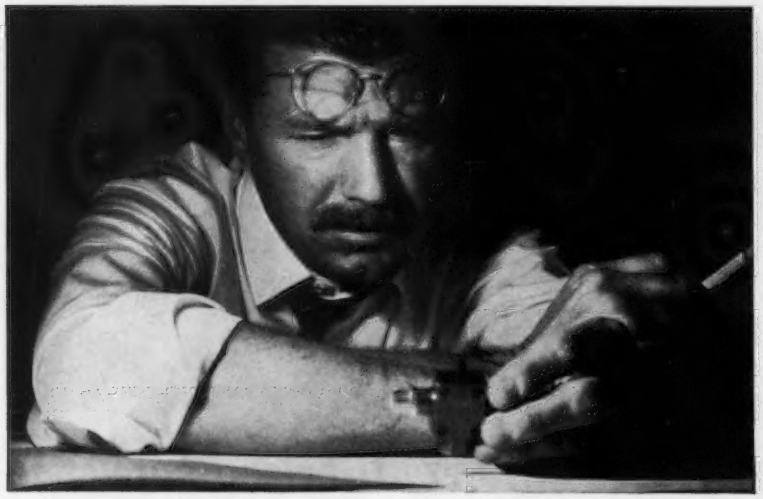

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Roebling carbon steel Aircord is made with galvanized or tinned finishes. It is available in a full range of sizes and constructions... in stock lengths or in complete assemblies...with fittings attached. Roebling also produces stainless steel Aircord and assemblies.

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Circle 25 on Inquiry Card

NEW Books

THE 1961 AEROSPACE YEAR BOOK—Official publication of the Aerospace Industries Association. Forty-second annual edition. American Aviation Publications (1001 Vermont Ave., Washington 5, D. C.), 483 pp., $10. This expanded standard reference of United States aircraft, missiles and spacecraft features: a complete pictorial review of the outstanding aerospace events of 1960; photographs, specifications, and 3-view drawings of planes and engines currently in production; photos and status reports on all missiles; a summary of industry and airline operations; a survey of aviation activities in DOD and the Armed Services; a digest of aircraft and missile research and development progress; a chronology of American aviation history; and a list of official records.

DICTIONARY OF AUTOMATIC CONTROL. By Robert J. Bibbero. Reinholt Publishing Corp. (430 Park Ave., New York 22, N. Y.), 1960. 282 pp., $6.00. A compact encyclopedic dictionary. Major topics covered include: control theory and basic concepts; computers and data processing; industrial machine and process control; aircraft and missile control and telemetry; control components and design factors. These topical areas are also listed in index form, where related terminology is grouped for ease of reference.

PRIMER ON TECHNICAL ARTICLES FOR ENGINEERS. By John L. Kent. American Industrial Writing Institute (P. O. Box 5453, Pasadena, Calif.), 1961. 13 pp., $0.75. A brochure on the "how" and "what" of technical article preparation. The following aspects of the art are treated in chapter form: what is a technical article; major types of articles; organization and writing; psychology of writing production; reader interest; self criticism; working with the editor. An editorial inquiry letter and a technical-article checklist are also included.

METALS HANDBOOK — Properties and Selection of Metals. Eighth edition, volume I. American Society for Metals (Metals Park (Novelty), Ohio), 1961. 1300 pp., $30.00. This authoritative work has been prepared under the direction of the Metals Handbook Committee of ASM. It is the first of a projected series of volumes which will cover all branches of metals engineering and metalworking. It presents the contributions of over 1300 metal specialists. It is thoroughly illustrated, and contains separate sections on: aluminum magnesium, super-strength alloys, titanium, special-purpose metals, precious metals, pure metals, etc. Coverage includes the newer generation of metals of special interest to aircraft and missile designers. Included is also a 14-page section on cost information for light-metal parts related to aircraft construction. A 64-page index is featured to simplify information searching.

UNITED STATES AIRCRAFT MISSILES AND SPACECRAFT 1961. National Aviation Education Council (1025 Connecticut Ave., N. W. Washington 6, D. C.), 156 pp., $1.50. This is an illustrated listing of aircraft and missiles in production. Booklet also includes a summary of outstanding aerospace events, records made and summary coverage in astronautics.

A MANUAL OF SPHERICAL AND PRACTICAL ASTRONOMY. By William Chauvenet. Dover Publications, Inc. (180 Varick St., New York 14, N. Y.), 1960. Two-volume, paperbound set $5.50. This is an unabridged and unaltered re-publication of the original work published in 1891. Considered as a standard work, by its comprehensive nature, this book is intended for the serious students of astronomy, and for navigators. Vol. I is devoted to the general problems of spherical astronomy and their special applications to nautical astronomy. Vol. II covers the theory and use of fixed and portable astronomical instruments including: telescopes, chronometers, clocks, the electrochronograph, the sextant and reflecting circles, the transit instrument and others.

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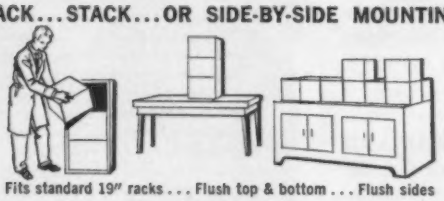

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Men On The Move

R. L. Dickson
Kiddie

ROBERT L. DICKSON, elected president of Walter Kidde & Co. He has been a member of the board of directors for the past three years.

JOHN A. WHITE is new assistant director of operations for Lockheed's California Division. He replaces ROBERT F. HURT, who becomes vice-president of the affiliate Grand Central Rocket Co.

T. H. Braun
SDC

ROBERT F. TANGREN, formerly associate manager of research at Aerojet-General's solid rocket plant, has been named manager of their newly created Space Propulsion Division.

MR. THEODOR H. BRAUN and DR. LAUNOR F. CARTER have been named vice-presidents of System Development Corporation.

WILLIAM C. HOUSE, appointed director of NERVA operations at Aerojet-General Corp. following an AEC and NASA contract award.

L. F. Carter
SDC

M. M. BLAIR and M. J. SARGEANT have been appointed to management posts at North American Aviation's Space and Informations Systems Division in Downey, Calif.

DR. WEBB HAYMAKER has been appointed assistant director for life sciences at the Ames Research Center, Moffett Field. Under his direction the laboratory will conduct research in space medical and behavioral sciences, space biology, and biotechnology.

Dr. J. C. Fletcher
Space General

DR. JAMES C. FLETCHER has been elected president of Space General Corp. and FRANK W. LEHAN, named executive vice-president of the newly created subsidiary of Aerojet-General.

EDWARD A. HEBDITCH has been appointed executive assistant to the president of Gulton Industries, Inc., will be in charge of corporate planning and programming.

F. W. Lehan
Space General

DR. CHRISTOPHER SHERMAN, an experimental plasma physicist, has joined the staff of the Geophysics Corp. of America where he will conduct studies on novel space vehicle propulsion systems.

PHILIP SPERGEL has been promoted to the newly created post of Director of Engineering for the Systems Div. of Epsco, Inc.

LT. GEN. WILLIAM H. TUNNER, USAF (Ret.) has been elected a director of Pioneer Aerodynamic Systems, Inc., in this position he will serve the company as a consultant.

W. H. Tunner
Pioneer

HOWARD M. WITTNER has been selected as the new manager of marketing at General Electric's Missile and Space Vehicle Department.

BERNARD B. WINGER has been named director of administration and defense contributing for the Data Recorders Div. of Consolidated Electrodynamics Corp.

ROY J. BENECCHI, appointed as vice-president and assistant to the president of Lear, Inc. Prior to this appointment he held several key management positions in the corporation.

R. J Benecchi
Lear

NORMAN JACOBSON has been appointed vice-president in charge of government contracts administration for the Electrospace Corp.

JOHN I. NESTEL, elected chairman of the board of directors at Consolidated Airborne Systems, Inc.

BERNARD M. BRENNER, named manager of the newly formed advanced development department at AMPEX Instrumentation Products Co.

B. M. Brenner
AMPEX

DR. ROBERT E. PAYNE has been named director of the Atlantic Missile Range office of the Aerospace Corporation.

JESSE L. JONES, appointed vice president - general manager of the Santa Monica division of Douglas Aircraft Co. and JAMES W. ROSS, appointed general manager of the El Segundo Div.

R. J. Brown
G E

ROBERT J. BROWN has been appointed head of the General Electric Company's ground and shipboard military electronics business.

NEIL M. BLAIR, president of the RF Products Div. of Amphenol-Borg Electronics Corp., has been named president of their FXR div.

ROBERT F. GARBARINI, named as chief engineer of Sperry Gyroscope Company's Air Armament Division, in this position he will be responsible for the engineering development of space and aeronautical equipment.

R. F. Garbarini
Sperry

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Operating Power: 250 MW standard, 100 MW special
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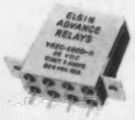

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The SINCLAIR-COLLINS VALVE Co.

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)
AKRON 11, OHIO

B190

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MUST INFORMATION

Please check in A & B below (one each) which best describes:

A. Your Job Function

- ....1. Management
- ....2. Design & Engineering
- ....3. Production
- ....4. Procurement

B. Type of Plant or Facility

- ....1. Airframe
- ....2. Propulsion
- ....3. Electronic Systems & Parts
- ....4. Mechanical Systems & Parts
- ....5. Raw & Processed Material
- ....6. Engineering & Research Services
- ....7. Military & Government Facilities
- ....8. Parts & Supplies
- ....9. Plant or Test Equipment
- ....0. Other

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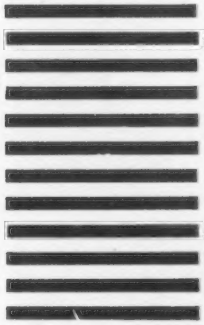

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YOUR NAME .....**TITLE** .....

COMPANY .....

PLANT ADDRESS .....

CITY .....**ZONE**.....**STATE**.....

MUST INFORMATION

Please check in A & B below (one each) which best describes:

A. Your Job Function

- ....1. Management
- ....2. Design & Engineering
- ....3. Production
- ....4. Procurement

B. Type of Plant or Facility

- ....1. Airframe
- ....2. Propulsion
- ....3. Electronic Systems & Parts
- ....4. Mechanical Systems & Parts
- ....5. Raw & Processed Material
- ....6. Engineering & Research Services
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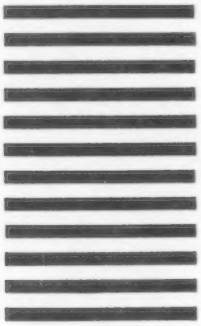

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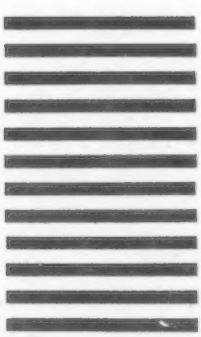

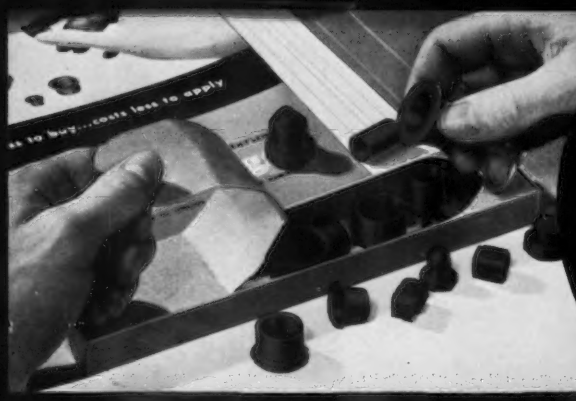

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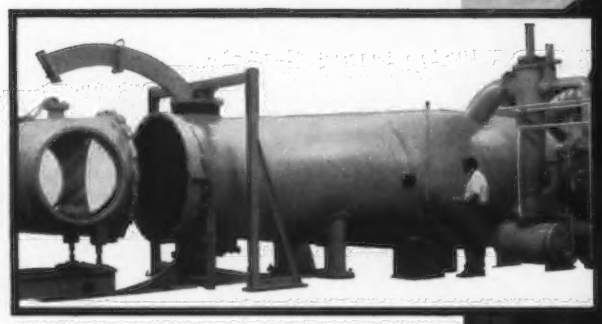

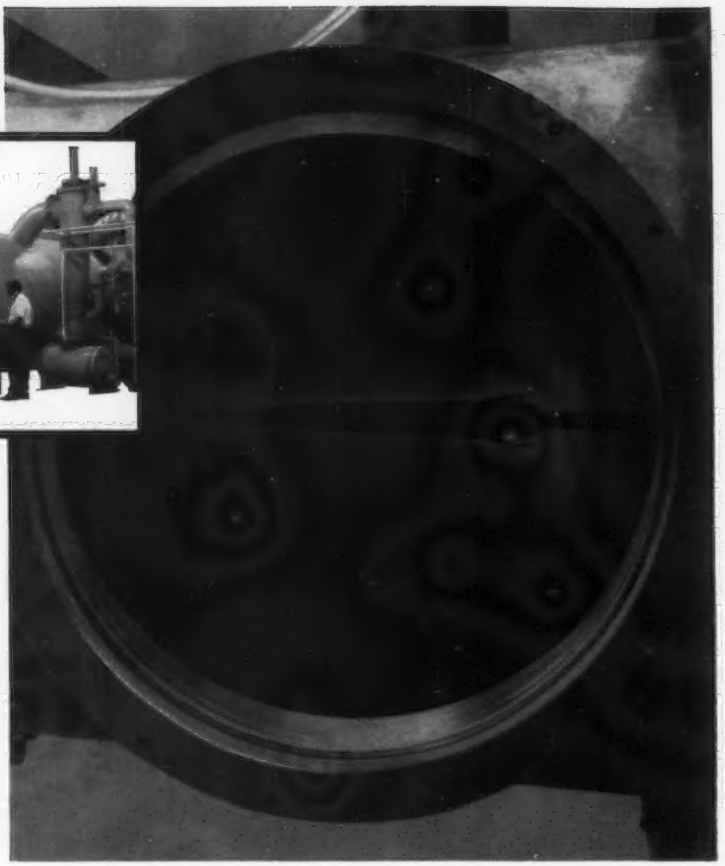

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